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SCHOOL SCIENCE AND MATHEMATICS

DECEMBER 1955

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

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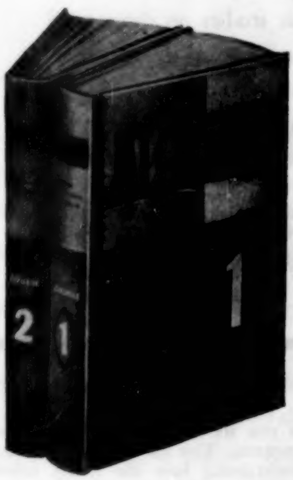

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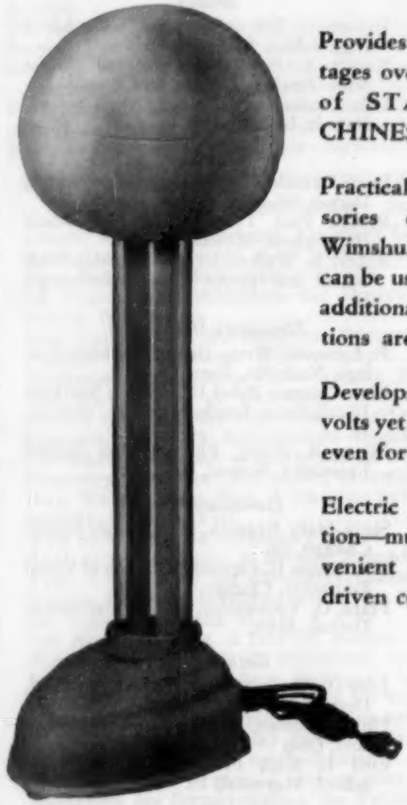

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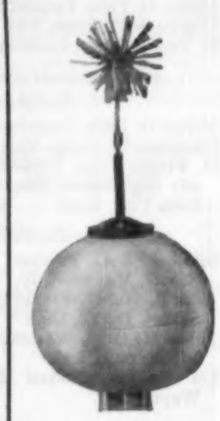

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SCHOOL SCIENCE AND MATHEMATICS

VOL. LV — DECEMBER, 1955 — WHOLE NO. 488

FIVE BASIC WAYS TO IMPROVE SCIENCE COURSES

STEVEN J. MARK
Kent State University, Kent, Ohio

In spite of the facts that we are living in a scientific era, that the demand for scientists exceeds the supply, that by 1956 the Soviet Union expects to surpass, both in quantity and quality, the United States in the number of qualified scientists, that we recognize the present and future shortage of secondary school science instructors, and that we agree on the paramount importance of scientific progress —in light of all these evidences—colleges, public school administrators, and science instructors look upon the continuous decrease in science enrolments in secondary schools as a trend in modern education. This is also true of the number of high school students taking higher mathematics. A glance at a few statistics will make this more evident.

PERCENTAGE OF PUPILS ENROLLED IN SECONDARY SCIENCE AND MATHEMATICS COURSES

	1890	1910	1915	1922	1928	1934	1947	1952	1954
General Science	—	—	—	18.3	17.5	17.8	18.3	19.4	
Biology	—	1.1	6.9	8.8	13.6	14.6	19.5	20.4	
Chemistry	10.1	6.9	7.4	7.4	7.1	7.6	8.6	7.6	
Physics	22.8	14.6	14.2	8.9	6.8	6.3	5.6	4.3	
Algebra	45.4	56.9	48.8	40.2	35.2	30.4			
Geometry	21.3	30.9	26.5	22.7	19.8	17.1			
Trigonometry	1.9	1.9	1.5	1.5	1.3	1.3			

The impact of this condition is being felt on college levels, for it is at the high school level that most future college engineers and scientists receive their initial training; not so much in subject matter, but rather an appreciation for the sciences and a desire to pursue them.

According to the New York *Times*, Soviet Union produced as many Ph.D's as the United States last year. In the United States degrees ran three to one in favor of the humanities. Soviet degrees ran three to one in favor of the various sciences including engineering. The number of students entering science training in Russia and the number completing their training exceeds that of United States by a substantial margin.

Reasons for such statistical trends as indicated in the preceding table are many. Some may be traced to 1890 when the Harvard Committee on College Entrance exerted a great influence on science enrolments. The science and mathematics courses were required of all high school students wishing to enter college. There were fewer electives, but on the other hand, the demand for scientific understanding of science phenomena was nowhere as great as at present. The secondary school population was more selective at this early period. Greater percentage of students dropped out of school before they reached the eleventh or twelfth grades. This accounted for the high percentage of students enrolled in the science and mathematics courses. Granting the above, may it not be modestly stated that learning and teaching conditions in our present schools are more conducive to science learning?

Without trying to elaborate on the causes and a defense for the trends, the plain fact is that present enrolments in these areas are dangerously down, and that the end is not in sight. The best that science teachers can do is to evaluate the content of these courses, and the methods used in teaching them. There is an urgent need for a plan of action rather than one of rationalization.

It is hoped that the following abbreviated discussion will, over a period of years, encourage additional boys and girls to study the sciences very early in life. Science educators are not interested in mere numbers. But it is a fact that the more students we have venturing into the sciences the less chance we have of losing some who may make a worthy contribution to society.

In organizing and in teaching a course of study, *it is paramount that a science teacher include experiences, activities, principles, and condensed factual content for which the students are READY*. These must be within the understanding of the majority of the students in the class. Teachers who neglect this basic principle in learning discourage students from taking additional courses in the sciences both on the

secondary and college levels. Physics teachers, more than others, are guilty of this omission, and they are, to a great degree, responsible for the continuous decrease in enrolments in physics. Physics is on its way out of the secondary school curriculum unless the teachers concerned present the content for which the students are ready, and they present it in such manner as to make it understandable to boys and girls.

Science instructors too frequently teach the identical content in the same manner each year even though variations in classes take place in terms of students' interests, needs, and levels of comprehension. When students lack mathematical skills, when their reading abilities and comprehension are low, and when their experiences are limited, the science teacher encounters from the start a mental block. The first few weeks should be spent learning about these deficiencies, and where ever possible helping them overcome them. Such an instructor may then be labelled a progressive educator for he is doing something about the weaknesses of boys and girls. He does not blame the teacher who had them the previous year.

Secondly, the course of study should include and be so organized that it will MOTIVATE the students. Boys and girls are best motivated when they feel a real need for the learnings in terms of their immediate felt needs or those not in too distant future. There is no implication that students learn only those principles which they are going to utilize today, tomorrow, or a month from today. Rather, they should be guided so as to see the application of Boyle's law and of Charle's law in the inflating of a tire on a cold day, the application of static electricity during the washing of silk clothing in a flammable liquid, the application of the law of inverse squares in the taking of a picture with a flash bulb, the application of the composition of the atmosphere in terms of jets and rockets, the application of organic compounds in medicine, dentistry, foods, and fuels, the application of acids in the body or in the car battery, the application of bases in washing of walls, the application of the periodic chart as a reference tool, and one may continue enumerating others. It is wise for teachers to bear in mind that their mere presence in the classroom for a period during which they "lecture" is no guarantee that boys and girls are engaged in a learning process. Best learning takes place when students are given an opportunity to participate in solving experiences in which they are interested, and those which they feel will add to their intellectual growth and personal happiness.

The third way to improve science courses is to organize them psychologically rather than logically. A science course should be organized in terms of the students' levels of maturation, needs and interests, understanding, and personal challenge. Students should know at all

times the directions in which they are moving, when they arrive there, and how much they have grown in competition with *themselves.* Science teachers, many others likewise, fail to take into consideration the fact that some students know more about the subject in September than what some will know in June. It is discouraging for the latter student to be compared continuously to the former.

One should not overlook the possibilities of the transfer of knowledge in setting up a course in the sciences. Psychologically it is known that transfer of this nature takes place when the laws of identity and generalization are considered. Transfer of training does not take place automatically. If a science teacher wants his pupils to secure transfer values from his course, he must stimulate and direct them in wanting and striving to obtain it. Furthermore, the amount of transfer depends on the degree of mastery of the material as related to basic principles. In summary of this fourth method it may be stated that it is the responsibility of the science teacher to give his students "something" they can claim possession of for more than a period after a test.

In planning a science course organized into fairly large functional units, stress the SOCIAL VALUE of the course. Growth is a continuous process. Science experiences must enable students to live more fully in the present and help prepare them to face the social problems of the future. This may be done by giving students time to study the implications that scientific advancements have on our social, political, and religious life. These experiences will benefit all students more than mathematical problems dealing with Ohm's law, ratios in Darwin's theory, or the determination of molecular weights. One such problem would be the significance of space satellites, and interplanetary travel.

Throughout the science courses, under no condition, disregard the importance of individual experiments where ever possible. This is true for the grades from kindergarten through the high school. There are experiments that a kindergarten youngster can do, provided they are in terms of her maturation, that will add as much to her growth pattern as an experiment that a senior may perform in chemistry. Just listen to a kindergarten girl tell the class why she waters a plant at certain intervals.

Science teachers have the best forms of visual education, actual equipments that students can experience with their five senses, however, they fail to use this form of education to its optimum.

Always laugh when you can, it is cheap medicine.
—Benjamin Franklin.

SURVEY OF RESEARCH IN ELEMENTARY SCHOOL SCIENCE EDUCATION*

JACQUELINE V. BUCK
Grosse Pointe Public Schools, Grosse Pointe, Michigan
AND
GEORGE GREISEN MALLINSON
Western Michigan College of Education, Kalamazoo, Michigan

INTRODUCTION

About two years ago the following statement[1] appeared in a journal devoted to research in science education:

> If science teachers were cognizant of the factors which contribute to student axhievement, abreast of the current developments in science relative to the objectives of science instruction, and alert to the use of the findings of scientific and educational research, a more realistic teacher training program could result, increasing vitality in the secondary school science classrooms of the nation.

The authors of this report have no argument with the above statement *per se*. Yet, they firmly believe that the implications of this statement apply to all teachers, in all subject-matter areas, and at all levels of instruction. They would also like to point out that to attain such a goal would indeed be a large order for any teacher, especially those in elementary schools. Few elementary teachers have available all the references and other source materials that contain the needed information. If such materials were available few elementary teachers would have time to read and glean the information from them. Further, there are many areas with which elementary teachers must be acquainted in addition to science.

These facts have been recognized by both the American Educational Research Association and the National Association for Research in Science Teaching. The first of the two organizations has for many years published the *Review of Educational Research*, a journal in which reviews of research in certain educational areas appear triennially. One of these review issues, somewhat technical in nature, dealt with the Natural Sciences and Mathematics. The last review devoted to these areas appeared in October 1951. Since that time the National Association for Research in Science Teaching has undertaken to produce an annual review of science education to replace that no longer

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* A report delivered at the 121st meeting of the American Association for the Advancement of Science at the University of California, Berkeley on December 29 to a joint session of the National Association for Research in Science Teaching, the AAAS Cooperative Committee on the Teaching of Science and Mathematics, the AAAS Section Q—Education, and the National Science Teachers Association; co-sponsored by the Western Society of Naturalists.

[1] Anderson, Kenneth E., "Improving Science Teaching Through Realistic Research." *Science Education*, XXXVII (February 1953), 55.

produced by the AERA. The first in this series of reviews[2,3] appeared in the February 1954 issue of *Science Education;* the second[4] in a later issue of the same journal. In 1950 there was published another somewhat technical review[5] that supplemented those that had appeared previously. However, many educators were aware that these technical reviews, while suitable for the specialist in science education, ordinarily were not suitable for the typical classroom teacher. Nor were they phrased in terminology easily understood and applied by the non-specialist. Hence, a number of non-technical reviews were produced to meet the need just indicated. Among the earliest efforts was one by Curtis;[6] among the more recent, two by Mallinson and Buck.[7,8]

Yet it is well-known that the field of elementary education is fruitful of a vast amount of research that has implications for elementary science instruction. And, much of this research deals specifically with elementary science. Thus it would seem that both technical and non-technical summaries of this research are needed frequently. It seems reasonable therefore that the implications of recent studies should be integrated with those of former in order to establish more definitely the avenues through which science teachers may improve science teaching. Such is the purpose of this non-technical summary of recent research in science teaching at the elementary-school level.

As is customary with non-technical summaries, no effort will be made to cite the sources wherefrom the implications emerge. Further for convenience, studies have been grouped under categories to which they seem logically to belong.

Studies in Science Curriculum

Grade Placement in Elementary Science

A number of studies were undertaken during the last year that

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[2] Buck, Jacqueline V. and Mallinson, George Greisen, "Some Implications of Recent Research in the Teaching of Science at the Elementary-School Level." *Science Education*, XXXVIII (February 1954), 81–101.

[3] Mallinson, George Greisen and Buck, Jacqueline V., "Some Implications and Practical Applications of Recent Research in the Teaching of Science at the Secondary-School Level." *Science Education*, XXXVIII (February 1954), 58–81.

[4] Anderson, Kenneth E., Smith, Herbert A., Washton, Nathan S., and Haupt, George W., "Second Annual Review of Research in Science Teaching." *Science Education*, XXXVIII, (December 1954), 333–65.

[5] Mallinson, George Greisen, "The Implications of Recent Research in the Teaching of Science at the Secondary-School Level." *Journal of Educational Research*, XLIII (January 1950), 321–42.

[6] Curtis, Francis D., Chapter XI entitled "Science" in *The Implications of Research for the Classroom Teacher*. Joint Yearbook of the American Educational Research Association and the Department of Classroom Teachers. Washington 2, D. C.: National Education Association, February 1939, Pp. 318.

[7] Mallinson, George Greisen and Buck, Jacqueline V., "Some Implications and Practical Applications of Recent Research in Science Education." *Journal of Education*, CXXXVII (October 1954), 23–26.

[8] Mallinson, George Greisen and Buck, Jacqueline V., "Science Education Research and the Classroom Teacher" *The Science Teacher*, XXII (February 1955, 20–2).

dealt with the grade placement of materials for elementary science instruction. In one of these studies an attempt was made to allocate principles of science to various grades in the elementary school. In another, an effort was made to develop a functional course in elementary science by allocating curricular materials to grade levels. The allocation was made in terms of the difficulty of the materials and their relationships to the interests that elementary school children might evidence at various age levels. In still another study, the development of a field guide for elementary schools was the objective. In the guide the facilities of the community were more or less parceled out for exploration at various grade levels.

In nearly all these studies the opinions of "experts" were used in determining the grade level at which the activities should be presented. These studies of course are similar to many that have been undertaken earlier. Apparently it is possible to develop graded lists of principles, study areas and activities for use at the elementary-school level. At least, the conclusions of these studies bear witness to such an assumption.

The authors of this report would like to suggest that efforts to improve elementary science curricula are salutary. However, they wonder if the emphasis of these studies has not been on subject matter that is quickly forgotten, rather than on the training given the child, the results of which are long retained. Children's interests do not grow in a regular sequence in the grades, but vary depending on the context and intensity of the situation of the moment. Further, nearly any area of science or any activity is suitable for nearly any grade level provided it is dealt with at the proper level of complexity.

Course Content in Elementary Science

During the last year the earth sciences and conservation were subjects of study as sources of materials for use in elementary science. Both studies dealt with essentially the same subject-matter areas and sought to find suitable concepts that could be developed into units for the use of teachers. In these studies it was found that many materials of geology, earth science and conservation were suitable for units in elementary science. Further, a number of supplementary aids such as Kodachrome slides were found to be suitable devices for enrichment of instruction.

Such efforts seem to have great merit since they result in the development of specific curricular materials for helping teachers whose backgrounds are frequently meager. Yet, caution must be suggested in that a unit on paper does not necessarily result in fruitful learning experiences.

Enrichment of Elementary Science

While the term "use of community resources" is used widely (and often platitudinously) in elementary education, only one study aimed specifically at the use of community resources for elementary science was uncovered in the recent literature. This one was concerned with the use of industrial resources in teaching science. In general the results of a questionnaire indicated that industry has much to offer for course enrichment at all levels of science instruction. Among these offerings are speakers, motion pictures and literature. Since the study was local in basis, its use is limited to schools in a local area.

However, it did indicate that a teacher might be able to find much in local industry to use in elementary science, a conclusion reached many years ago with respect to secondary science.

Studies in Learning and Teaching

Elementary Science and Problem Solving

One of the objectives of science education, namely the development of problem-solving skills has become the subject of a number of learning studies during the last several years. Such is long overdue since this objective was well described in the Thirty-first Yearbook of the National Society for the Study of Education (1932) and in the Forty-sixth Yearbook of the National Society for the Study of Education (1947).

One of these studies attempted to identify specifically the features of the problem solving approach and how the methodology could be used in teaching certain areas of elementary science. Another study dealt with the relationships between tests of reading for problem-solving in science and for general ability. Another dealt with the growth of problem-solving skills resulting from incidental teaching as compared with growth resulting from direct teaching.

In general, these studies point out that problem-solving skills can be taught to elementary school children, that direct teaching efforts are far more successful than incidental, and that success depends to a great extent on the mental maturity of the children. The most significant factor however seems to be the existence of a definitely planned learning situation.

None of these studies of course produced new evidence. They did however emphasize that elementary science can be more than the study of natural objects. Further, they do indicate a definite growth in interest in searching for the most suitable techniques for teaching problem solving through elementary science. However, this field of study is still "wide open."

Factors that Enhance Learning in Elementary Science

Several studies were undertaken to learn the effects of intelligence, reading ability and social status on learning in elementary science. One study in particular compared the achievement in science between gifted and slow-learning students.

While these studies seemed to follow acceptable research techniques they merely added more evidence to what is already known conclusively, namely (1) the more intelligent children, (2) the children with high-level reading ability, and (3) the children with the highest social status and levels of adjustment achieve more in science than children with lesser amounts of these characteristics. It would seem that researchers in elementary science would do well to examine the research findings in the psychology of learning that apply to science as well as to other fields. It would save much time and effort now being devoted to research which is essentially redundant.

Learning Time and Space Concepts

Two studies were undertaken this last year with respect to the learning of time and space concepts in the area of elementary science. It is admittedly difficult to teach these concepts so that children have "psychological ownership" of their implications. These studies show obviously that the concepts can be taught more successfully as children mature, that direct efforts are more successful than incidental and that areas such as earth science and astronomy are more easily understood if children understand concepts of time and space.

However, these studies also indicate the need for more research to determine techniques that will enhance children's understanding of space and time relationships.

Enrichment of Learning Experiences

As with secondary science and all other areas of elementary education, efforts are constantly being made to find ways to enrich learning activities with up-to-date materials and out-of-classroom experiences. The studies dealing with field trips point out only what has been known for many years, namely, that the objectives of elementary science can be attained effectively by such activities.

It is significant to note also that efforts to bring atomic energy into elementary science have been successful. While much still needs to be done, it is obvious that this topic, of such vital interest to children, can be taught effectively in the elementary grades.

Studies in Teacher Education

Science Preparation of Elementary Teachers

A perennial among elementary science studies, the subject-matter

backgrounds of elementary teachers, was again undertaken. The study failed to prove anything new. It added a fragment to already weighty evidence, that elementary teachers usually have little background in science, and that what they do have is ordinarily too specialized to be of optimal value. Since the study failed to deal with a new topic, the significance of the conclusions is a matter of doubt.

The Desirable Science Program for Prospective Elementary Teachers

One study whose title bore great promise failed to provide much more than statements already made many times. In an effort to decide the type of science program suitable for elementary teachers, the investigator surveyed books and journals, and solicited the opinions of college professors. It was concluded that the training should be functional, should be selected from all areas of science, and should emphasize areas that concern children. The conclusions are likely to offend no one.

Summary

Since one can hardly justify a summary of a summary, it was decided that a few recommendations might be in order:

1. Research workers in science education should explore the literature before undertaking studies. Often they repeat studies whose conclusions are sufficiently definitive to warrant no further study of the problem.
2. Research workers in science education may well examine the aims of their studies. Many studies, even though all established rules of research were followed with meticulous care, could never have produced other than trivial information.
3. Research workers in science education should undertake more studies that provide solutions rather than merely point out more problems, many of which are already known.

THE WHITE HOUSE CONFERENCE

The White House Conference idea rests on belief in people, in their goodness, in their desire and their will to improve matters for themselves and for others. It rests on the belief that when people are given the facts their judgment will lead them to wise decisions; that people want good education for their own children and for other people's children; that people are willing to provide good education by spending enough of their own money for good education. It rests on the belief that people are entitled to know what they get for the money they spend and that the people in their local communities should control education, for schools are established to *assist* parents and not to supplant them.

S. M. Brownell
U. S. Commissioner of Education

SOLUTION OF THE QUADRATIC BY HYPERBOLIC FUNCTIONS

Arthur Porges
Los Angeles City College, 855 North Vermont Street, Los Angeles 29, California

Although the determination of the real roots of a quadratic equation by the use of a trigonometric substitution is a well-known device, a similar method involving hyperbolic functions may be new.

Given the equation

$$AX^2+BX+C=0, \qquad (C\neq 0) \tag{1}$$

with real coefficients and $A>0$, we carry out the following transformation. Let

$$X=\sqrt{\frac{|C|}{A}}\,e^t,$$

and (1) becomes

$$Ce^{2t}+C+B\sqrt{\frac{|C|}{A}}\,e^t=0. \tag{2}$$

Dividing (2) by e^t, and simplifying the result, we may write (2) as

$$\frac{e^t\pm e^{-t}}{2}=\frac{-B}{2C}\sqrt{\frac{|C|}{A}}, \tag{3}$$

where the ambiguity of sign derives from C, which may be either positive or negative.

For purposes of clarification, we may distinguish among the following four cases.

Case I. ($C>0$, $B<0$) In this case, both roots of (1) are positive, and we may take the positive sign in the left member of (3), writing the equation in the form

$$\text{Cosh } t=\frac{-B}{2C}\sqrt{\frac{|C|}{A}}. \tag{4}$$

The roots of (1), since $\text{Cosh }(-t)=\text{Cosh } t$, are then given by

$$\sqrt{\frac{|C|}{A}}\,e^{\pm t}, \tag{5}$$

where t is taken from a table of hyperbolic functions and entered in one for powers of e.

Case II. ($C>0$, $B>0$) Here both roots are negative, and the simplest procedure is to change their sign, which merely affects that of B. We may then use (5), remembering to call the numerical results negative.

Case III. ($C<0$, $B>0$) The roots have unlike signs, and we use the negative sign in the left member of (3), writing the equation as

$$\text{Sinh } t = \frac{-B}{2C}\sqrt{\frac{|C|}{A}}. \tag{6}$$

Here t is obviously positive, and since changing the signs of the roots of (1) affects only that of B, it follows that both roots are given in absolute values by (5). We may note that since $B>0$, the negative root has the greater absolute value, and will result from the positive exponent of e.

Case IV. ($C<0$, $B<0$) In this case, again of roots with unlike signs, we use (5), noting that since now the positive root is the greater in absolute value, it will be given by the positive exponent.

The trivial case, $B=0$, $C<0$, leads to the equation Sinh $t=0$, whence the roots are equal in absolute value but opposite in sign. In these circumstances, restricting our discussion to only the principal value of the radical of (3) is no longer justified, and the roots are

$$\pm\sqrt{\frac{|C|}{A}} \tag{7}$$

ENROLLMENT IN SCHOOLS AND COLLEGES

Public and private schools and colleges in the continental United States will enroll, this fall, an estimated 39,557,000 students—1,657,000 more than a year ago—S. M. Brownell, Commissioner of Education, U. S. Department of Health, Education, and Welfare, announced September 8.

The increase is divided as follows: elementary (kindergarten through grade 8), 1,300,000; secondary, 258,000; colleges and universities, 99,000.

Last year, enrollment was divided as follows: elementary (kindergarten through grade 8), 27,738,000; secondary, 7,422,000; colleges and universities, 2,740,000.

The Commissioner pointed out that this is the 11th consecutive year of increased total enrollment in schools and colleges. Forecasts for the ten years through 1964–65 indicate substantial increases for each year ahead, with a diminished rate of increase in elementary schools toward the end of the ten-year period.

The Commissioner stated that, assuming one new classroom is needed for each 30 additional pupils enrolled in elementary and secondary schools (both public and nonpublic), the increase of enrollment from 1954–55 to 1955–56 calls for an increase of 52,000 classrooms over the number available last year.

THE MORLEY TRIANGLE AND OTHER TRIANGLES

John Satterly
University of Toronto, Toronto Canada

Early in this century Professor Frank Morley proved the celebrated theorem about the plane triangle which is associated with his name. The Theorem is "The three points of intersection of the adjacent trisectors of the angles of any plane triangle form an equilateral triangle." It is illustrated in Fig. 1.[1]

Morley's Theorem is so pretty that I feel no apology in providing our readers with more accessible proofs which I have taken, with alterations, from the *Mathematical Gazette* of London, England.[2] The first is by C. H. Chepmell, the second by J. M. Child; some will prefer one proof, some the other.

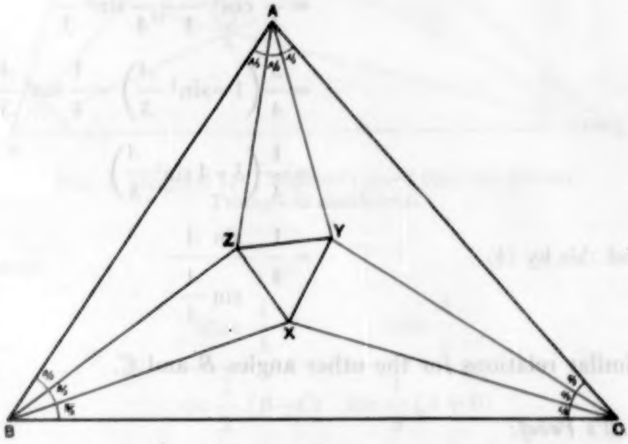

Fig. 1. The intersections of adjacent trisectors of the angles A, B, C of a triangle ABC give Morley's Triangle XYZ

The following expressions are required in the proofs. I give them here ahead of their use so as not to disturb the argument. I omit the angle sign $\angle$ and the degrees sign $^\circ$.

[1] Morley says he first mentioned this theorem to some friends at Cambridge, England in 1904 and first published it in the *Mathematical Association of Japan Journal for Secondary Education* in Vol. 6, 1924 p. 260. It is mentioned in Morley's paper on the Estension of Clifford's Chain Theorem in *American Journal of Mathematics*, Vol. 51, 1929, p. 469. A diagram of this triangle is shown in *Mathematical Snapshots* by H. Steinhaus (Oxford University Press, New York, 1950) p. 4.

[2] *Mathematical Gazette* (London) Vol. XI, 1922–1923, "Morley's Theorem" by C. H. Chepmell, p. 85; "Proof of Morley's Theorem" (by Euclid, Book III) by J. M. Child, p. 171. "Geometrical Proof of Morley's Theorem" by R. F. Davis, p. 85. See also F. H. Macneish who proves his theorem but gives it no name in *American Mathematical Monthly* Vol. XXXI, 1924 p. 310.

They are

(1) $60-\frac{A}{3}=\frac{A+B+C}{3}-\frac{A}{3}=\frac{B+C}{3}$

(2) $60+\frac{A}{3}=60+\left(60-\frac{B+C}{3}\right)=180-\left(60+\frac{B+C}{3}\right)$,

(3) hence $\sin\left(60+\frac{A}{3}\right)=\sin\left(60+\frac{B+C}{3}\right)$

(4) $\sin A=3\sin\frac{A}{3}-4\sin^3\frac{A}{3}=\sin\frac{A}{3}\left(3-4\sin^2\frac{A}{3}\right)$

(5) $\sin\left(60+\frac{A}{3}\right)\sin\left(60-\frac{A}{3}\right)=\sin^2 60\cos^2\frac{A}{3}-\cos^2 60\sin^2\frac{A}{3}$

$$=\frac{3}{4}\cos^2\frac{A}{3}-\frac{1}{4}\sin^2\frac{A}{3}$$

$$=\frac{3}{4}\left(1-\sin^2\frac{A}{3}\right)-\frac{1}{4}\sin^2\frac{A}{3}$$

$$=\frac{1}{4}\left(3-4\sin^2\frac{A}{3}\right)$$

(6) and this by (4) $$=\frac{1}{4}\,\frac{\sin A}{\sin\frac{A}{3}}$$

with similar relations for the other angles B and C.

Chepmell's Proof:

Produce BZ, CY (Fig. 2) to meet in L. We shall prove that $ZL=YL$. We have $ZL=BL-BZ$ and since in a triangle sides are proportional to the sines of opposite angles or to sines of the supplements of opposite angles we have in the $\triangle BLC$

$$\frac{BL}{BC}=\frac{\sin\angle BCL}{\sin\angle BLC}=\frac{\sin\frac{2}{3}C}{\sin\frac{2}{3}(B+C)},$$

and in the

$$\left(\triangle BAZ,\right) \quad \frac{BZ}{AB}=\frac{\sin\angle BAZ}{\sin\angle BZA}=\frac{\sin\dfrac{A}{3}}{\sin\dfrac{1}{3}\,(A+B)}$$

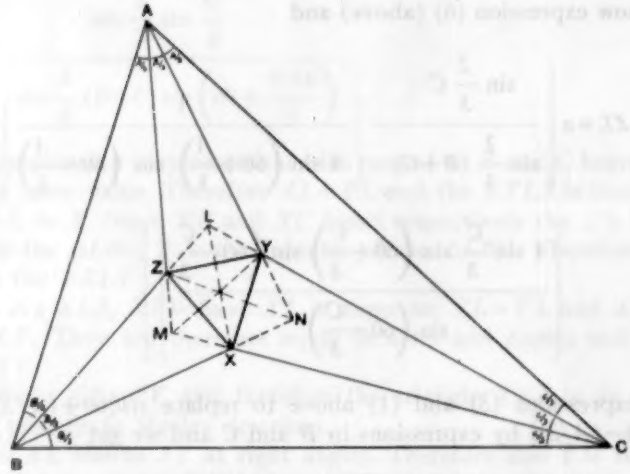

FIG. 2. Diagram for Chepmell's proof that the Morley Triangle is equilateral.

Therefore

$$ZL=\frac{a\sin\dfrac{2}{3}\,C}{\sin\dfrac{2}{3}\,(B+C)}-\frac{c\sin\dfrac{A}{3}}{\sin\dfrac{1}{3}\,(A+B)}.$$

Replace c by

$$\frac{a\sin C}{\sin A} \quad \text{and} \quad \frac{1}{3}\,(A+B) \quad \text{by} \quad \left(60-\frac{C}{3}\right),$$

see (1) above

$$\therefore\ ZL=a\frac{\sin\dfrac{2}{3}\,C}{\sin\dfrac{2}{3}\,(B+C)}-\left(a\,\frac{\sin C}{\sin A}\right)\left[\frac{\sin\dfrac{A}{3}}{\sin\left(60-\dfrac{C}{3}\right)}\right]$$

$$=a\left\{\frac{\sin\frac{2}{3}C}{\sin\frac{2}{3}(B+C)}\left[\frac{\sin\frac{A}{3}}{\sin A}\right]\left[\frac{\sin C}{\sin\left(60-\frac{C}{3}\right)}\right]\right\}$$

Use now expression (6) (above) and

$$ZL=a\left\{\frac{\sin\frac{2}{3}C}{\sin\frac{2}{3}(B+C)}\cdot\left[\frac{1}{4\sin\left(60+\frac{A}{3}\right)\sin\left(60-\frac{A}{3}\right)}\right]\right.$$

$$\left.\left[\frac{4\sin\frac{C}{3}\sin\left(60+\frac{C}{3}\right)\sin\left(60-\frac{C}{3}\right)}{\sin\left(60-\frac{C}{3}\right)}\right]\right\}$$

Use expressions (3) and (1) above to replace *sin*$[60+(A/3)]$ and *sin*$[60-(A/3)]$ by expressions in B and C and we get

$$ZL=a\left\{\frac{2\sin\frac{C}{3}\cos\frac{C}{3}}{2\sin\frac{B+C}{3}\cos\frac{B+C}{3}}\cdot\frac{\sin\frac{C}{3}\sin\left(60+\frac{C}{3}\right)}{\sin\left(60+\frac{B+C}{3}\right)\sin\frac{B+C}{3}}\right\}$$

$$=a\frac{\sin\frac{C}{3}}{\sin\frac{B+C}{3}}\left\{\frac{\cos\frac{C}{3}}{\cos\frac{B+C}{3}}\cdot\frac{\sin\left(60+\frac{C}{3}\right)}{\sin\left(60+\frac{B+C}{3}\right)}\right\}$$

$$=a\,\frac{\sin\frac{C}{3}}{\sin\frac{B+C}{3}}$$

$$\cdot\left\{\frac{\cos\frac{C}{3}\sin\left(60+\frac{B+C}{3}\right)-\cos\frac{B+C}{3}\sin\left(60+\frac{C}{3}\right)}{\cos\frac{B+C}{3}\sin\left(60+\frac{B+C}{3}\right)}\right\}$$

$$=a\,\frac{\sin\dfrac{C}{3}}{\sin\dfrac{B+C}{3}}\left\{\frac{\dfrac{1}{2}\sin\dfrac{B}{3}}{\cos\dfrac{B+C}{3}\sin\left(60+\dfrac{B+C}{3}\right)}\right\}$$

$$=a\,\frac{\sin\dfrac{B}{3}\sin\dfrac{C}{3}}{\sin\dfrac{2}{3}(B+C)\sin\left(60+\dfrac{B+C}{3}\right)}$$

This expression is symmetrical with respect to B and C hence YL has the same value. Therefore $ZL=YL$ and the $\triangle YLZ$ is isosceles.

Join L to X. Since XB and XC bisect respectively the $\angle$'s LBC, LCB of the $\triangle LBC$, X is the Incenter of the $\triangle LBC$. Therefore XL bisects the $\angle ZLY$.

The $\triangle$'s XLZ, XLY have XL in common, $ZL=YL$ and $\angle XLZ=\angle XLY$. They are therefore equal in sides and angles and thus $XZ=XY$.

Similarly $XZ=ZY$ and therefore the triangle XYZ is an equilateral triangle as Morley describes.

Note: XL bisects ZY at right angles. Therefore also YM bisects XZ at right angles and ZN bisects XY at right angles. Hence the three joins XL, YM, ZN, are concurrent (Fig. 2).

Child's Proof:

Trisect the angles B and C of $\triangle ABC$ (Fig. 3). Let the trisectors adjacent to BC meet in X. Make the angles BXZ, CXY equal respectively to $60+(C/3)$ and $60+(B/3)$ the lines XZ, BY meeting the other trisectors of B and C in Z and Y.

The

$$\angle BZX=180-\left(60+\frac{C}{3}\right)-\frac{B}{3}=60+\frac{A}{3}\cdot$$

Similarly

$$CYX=60+\frac{A}{3}\cdot$$

Let BZ, CY meet in L. Since X is the Incenter of the $\triangle BLC$ and XZ and XY are equally inclined to BL, CL respectively, $XZ=XY$. The

$$BXC=180-\frac{B+C}{3},$$

therefore the

$$\angle ZXY = 360 - \left(180 - \frac{B+C}{3}\right) - \left(60 + \frac{B}{3}\right) - \left(60 + \frac{C}{3}\right) = 60°$$

Therefore the triangle XYZ is equilateral.

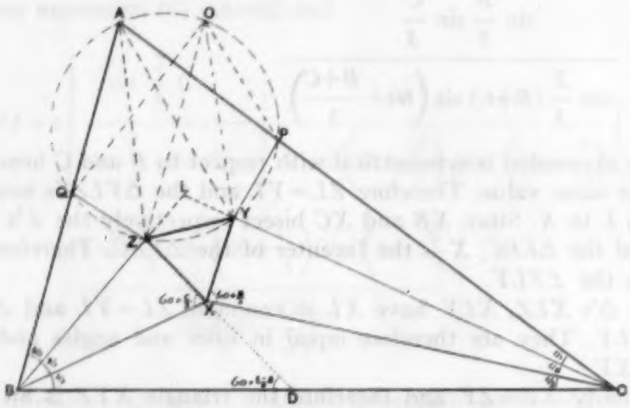

FIG. 3. Diagram for Child's proof that the Morley Triangle is equilateral.

Join ZA, YA. We must now show that ZA, YA trisect $\angle A$. To do this make $BQ = BX$ and $CP = CX$. Therefore the triangles BQZ, BXZ are equal in all respects. So also are the triangles CPY, CXY. Hence $QZ = ZX = XY = YP$. Also

$$\angle QZY = 360 - \left(60 + \frac{A}{3}\right) - \left(60 + \frac{A}{3}\right) - 60 = 180 - 2\frac{A}{3}$$

Similarly

$$PYZ = 180 - 2\frac{A}{3}.$$

Therefore the points Q, Z, Y, P are concylic and since the chords QZ, ZY, YP are equal they will subtend equal angles at any point such as O on the circumference of the circle $QZYP$. These equal angles will be necessarily each equal to $A/3$. Therefore the whole arc $QZYP$ subtends at any point on the circumference of this circle an angle equal to A. Therefore the point A of the triangle ABC lies on the circle $QZYP$ and ZA, YA trisect the angle at A. Thus the theorem is proved.

The Lengths of the Sides of the Morley Triangle

In any triangle the sides are proportional to the sines of the op-

posite angles (or to the sines of the supplements of the opposite angles). Use Fig. 3. In

$$\triangle BXC, \angle BXC = 180 - \left(\frac{B+C}{3}\right)$$

and therefore

$$BX = \frac{a \sin \frac{C}{3}}{\sin \frac{B+C}{3}}$$

In BXZ

$$XZ = BX \frac{\sin \frac{B}{3}}{\sin\left(60+\frac{A}{3}\right)}$$

$$\therefore\ XZ = a \frac{\sin \frac{B}{3} \sin \frac{C}{3}}{\sin\left(60+\frac{A}{3}\right) \sin \frac{B+C}{3}}$$

and this by Expression (1)

$$= \frac{a \sin \frac{B}{3} \sin \frac{C}{3}}{\sin\left(60+\frac{A}{3}\right) \sin\left(60-\frac{A}{3}\right)}$$

$$= \frac{a \sin \frac{B}{3} \sin \frac{C}{3}}{\sin A/4 \sin A/3} \quad \text{by Exp. (6)}$$

$$= 4 \frac{a}{\sin A} \sin \frac{A}{3} \sin \frac{B}{3} \sin \frac{C}{3},$$

and of course $b/\sin B$ or $c/\sin C$ may replace $a/\sin A$ in this expression.

The expression may be made more symmetrical by using the radius R of the circum-circle. We know from elementary Trigo-

nometry that $R=a/(2\sin A)=b/(2\sin B)=c/(2\sin C)$

$$\therefore\ XZ=8R\sin\frac{A}{3}\sin\frac{B}{3}\sin\frac{C}{3}\cdot$$
$$=ZY=YZ.$$

Extension of Morley's Theorem

So far we have used only the adjacent trisectors of the interior angles A, B, C of the triangle. W. J. Dobbs[3] shows that the trisection of the angles A, B, C may be extended to include the trisection of the angles $A+2\pi$, $B+2\pi$, $C+2\pi$ and also of the angles $A+4\pi$, $B+4\pi$, $C+4\pi$. Doing this the intersections of the trisectors give a total of 27 Morley triangles of which 18 only are equilateral. Gino Loria[4] has worked out the lengths of the sides of all these triangles.

Concurrences and Collinearity

E. J. Hopkins[5] has given a variation of the Morley construction.

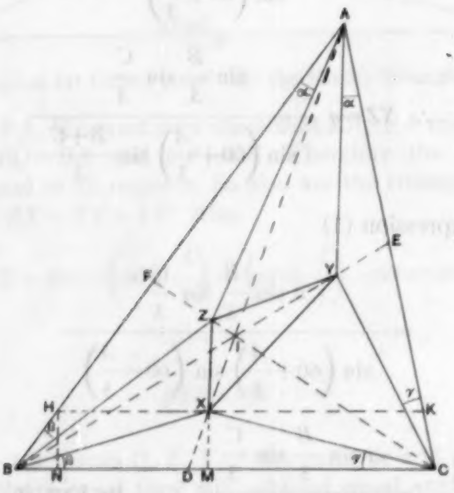

FIG. 4. Hopkins' diagram, where the dividing lines make angles α, β, γ with the sides.

[3] W. J. Dobbs, *Mathematical Gazette*, Vol. XXII, 1938, p. 50, "On Morley's Triangle."

[4] Gino Loria, Professeur à l'Université de Gênes, *Mathematical Gazette*, Vol. XXIII, 1939, p. 364, "Triangles équilatéraux dérivés d'un triangle quiconque." A letter from Professor Morley, also references to some other papers are given here. See also F. G. Taylor and W. L. Marr in *Proc. Edinburgh Math. Society*, Vol. XXXII, 1914 pp. 119, 132, 136.

[5] E. J. Hopkins, *Mathematical Gazette*, Vol. XXXIV, 1950, p. 129, "Some Theorems of Concurrence and Collinearity." See also A. G. Burgess. *Proc. Edinburgh Math. Soc.* Vol. XXXII pp. 1914, p. 58, "Concurrences of lines joining vertices of a triangle to opposite vertices of triangles on its sides.

He takes the triangle ABC (Fig. 4) and three points within it such that

$$\angle XBC=\angle ZBA=\beta \quad \angle XCB=\angle YCA=\gamma \quad \angle YAC=\angle ZAB=\alpha$$

and proves (a) that the lines AX, BY, CZ are concurrent.

To show this draw AX and produce it to cut BC in D. Draw XM perpendicular to BC. Through X draw the line HXK parallel to BC to meet AB in H and AC in K. Draw HN perpendicular to BC. We have $HX=BM-BN=XM(\cot\beta-\cot B)$. Similarly $XK=XM(\cot\gamma-\cot C)$. Also by parallels

$$\frac{BD}{DC}=\frac{HX}{XK}$$

$$\therefore \frac{BD}{DC}=\frac{\cot\beta-\cot B}{\cot\gamma-\cot C}$$

Similarly if BY and CZ produced cut CA in E and AB in F respectively

$$\frac{EC}{EA}=\frac{\cot\gamma-\cot C}{\cot\alpha-\cot A}$$

and

$$\frac{AF}{FB}=\frac{\cot\alpha-\cot A}{\cot\beta-\cot B}$$

Hence

$$\frac{BD}{DC}\times\frac{CE}{EA}\times\frac{AF}{FB}=1.$$

Therefore by Ceva's Theorem AX, BY, CZ are concurrent, at point I, say.

Hopkins also mentions without proof that if BZ, CY meet in L, AZ, CX meet in M and AY, BX meet in N that, see Fig. 5,

(b) AL, BM, CN are concurrent meeting, say, in J.

(c) XL, YM, ZN are concurrent meeting, say, in K.

(d) I, J, K are collinear.

Statement (c) was shown earlier in this paper to be true for the special case where the angles of the triangle are trisected giving Morley's triangle. (Fig. 2) The statements are further illustarted in Fig. 6, a Morley triangle diagram.

Hopkins deals further with the properties of the hexagon $XMZLYN$ but we omit this part of his paper.

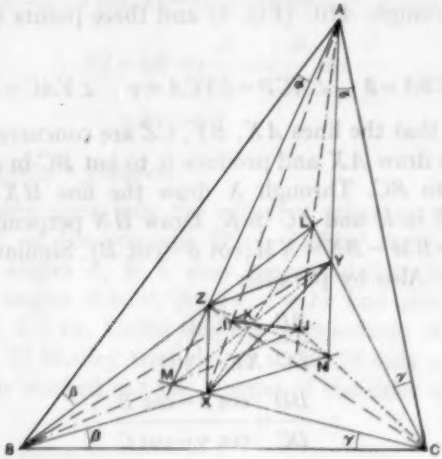

FIG. 5. Hopkins' diagram illustrating his theorems of concurrence and collinearity.

The angles α, β, γ may be taken external to the $\triangle ABC$ as in Fig. 7 where the angles have the same magnitudes as in Fig. 5 and in Fig. 8 when they are much larger.

FIG. 6. Hopkins' theorems illustrated on a Morley Triangle diagram.

Other submultiples of the angles A, B, C

We have now (1) the bisectors of the angles A, B, C meet in the incenter O of the triangle; (2) the trisectors of the angles A, B, C give, by their interesections, the Morley Triangle, and (3) the Hop-

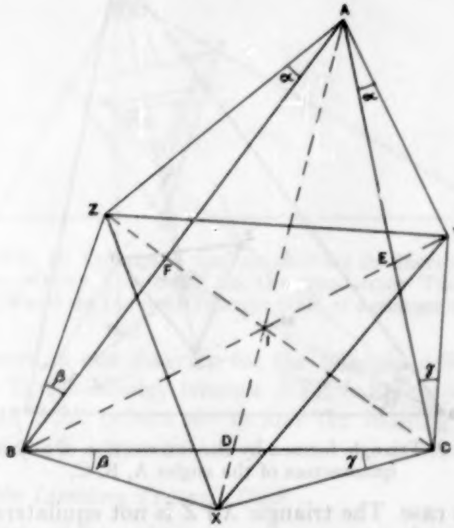

FIG. 7. Hopkins' diagram where the angles α, β, γ are external to the triangle but of the same size as in Figs. 5 and 6.

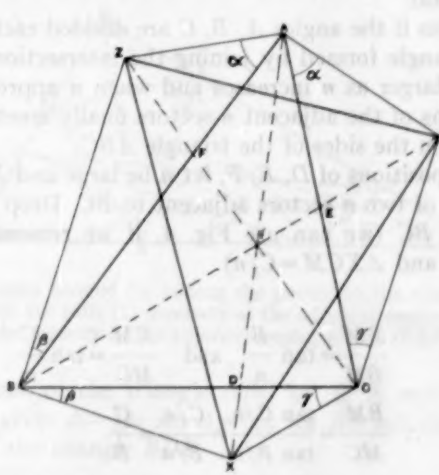

FIG. 8. Another Hopkins' diagram where the external angles α, β, γ are larger than in Fig. 7.

kins' theorems of concurrency and collinearity. We now inquire what happens if we divide each of the angles A, B, C into four equal parts and consider the intersections of adjacent quadrectors. Fig. 9

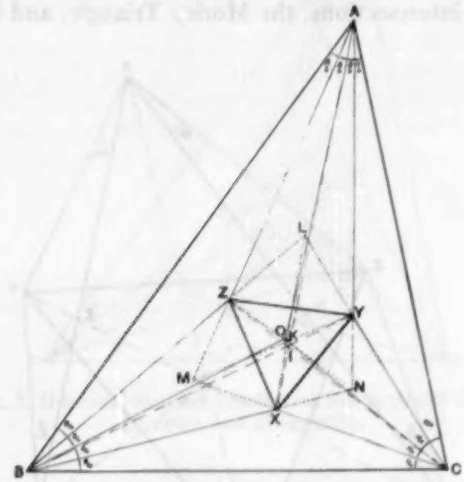

FIG. 9. Triangle formed by the intersection of adjacent quadsectors of the angles A, B, C.

illustrates this case. The triangle XYZ is not equilateral although it may look so, but of course the collinearities and concurrencies proved by Hopkins still hold. Of course, if ABC is equilateral $\triangle XYZ$ is also equilateral.

What happens if the angles A, B, C are divided each into n equal parts? The triangle formed by joining the intersections of adjacent n-sectors gets larger as n increases and when n approaches infinity the intersections of the adjacent n-sectors finally meet at D, E, and F, practically on the sides of the triangle ABC.

To find the positions of D, E, F, let n be large and X be the point of intersection of two n-sectors adjacent to BC. Drop a perpendicular XM upon BC (we can use Fig. 4, if we remember that now $\angle XBM = B/n$ and $\angle XCM = C/n$).
Then

$$\frac{XM}{BM} = \tan\frac{B}{n} \quad \text{and} \quad \frac{XM}{MC} = \tan\frac{C}{n}$$

$$\therefore \quad \frac{BM}{MC} = \frac{\tan C/n}{\tan B/n} = \frac{C/n}{B/n} = \frac{C}{B}$$

when n is very large and as $n \to$ infinity X and M moves to D. Similarly for E and F. Thus we get the triangle DEF where D, E, F divide the

sides in the *inverse* ratio of the adjacent angles i.e., $BD:CD::C:B$. An application of Ceva's Theorem shows that AD, BE, CF are concurrent.

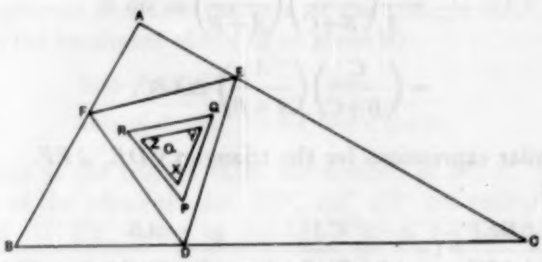

Fig. 10. Composite diagram showing the Incentor *O*, the Morley Triangle *XYZ*, the Quadsector Triangle *PQR* and the Limiting Triangle *DEF*, of a triangle *ABC*.

Fig. 10 shows in one diagram for the triangle ABC the incenter O (where $n=2$), the Morley triangle XYZ (where $n=3$), the Quadsector triangle PQR (where $n=4$) and the limiting triangle DEF (where $n=$ infinity).

The Area of the Limiting Triangle DEF

This is obtained by subtracting the sum of the three triangles BDF, CDE, AEF from the whole triangle ABC (Fig. 10 or 11).

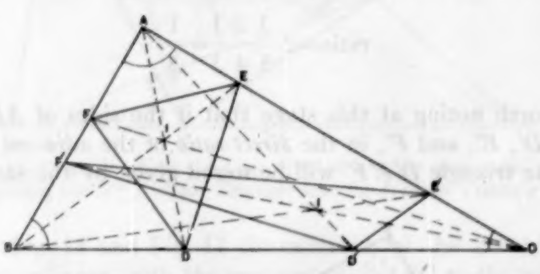

Fig. 11. Triangles formed by joining the points on the sides of the triangle *ABC* which divide the *sides* (1) inversely as the adjacent *angles*, giving *DEF* and (2) divide the sides directly as the adjacent *angles*, giving *D'EF'*.

Denote the area of the triangle ABC by Δ. A well-known Trigonometry rule gives $\Delta=\frac{1}{2}bc\sin A=\frac{1}{2}ca\sin B=\frac{1}{2}ab\sin C$.

The area of the triangle BDF

$$=\frac{1}{2}BD\cdot BF\sin B$$

$$=\frac{1}{2}\left(\frac{C}{B+C}a\right)\left(\frac{A}{A+B}c\right)\sin B$$

$$=\frac{1}{2}\left(\frac{C}{B+C}\right)\left(\frac{A}{A+B}\right)ac\sin B$$

$$=\left(\frac{C}{B+C}\right)\left(\frac{A}{A+B}\right)\triangle ABC.$$

with similar expressions for the triangles CDE, AEF.

Hence

$$\frac{\text{Area of }\triangle DEF}{\text{Area of }\triangle ABC}=1-\frac{CA}{(A+B)(B+C)}-\frac{AB}{(B+C)(C+A)}-\frac{BC}{(C+A)(A+B)}$$

$$=\frac{(A+B)(B+C)(C+A)-CA(C+A)-AB(A+B)-BC(B+C)}{(A+B)(B+C)(C+A)}$$

$$=\frac{2\,ABC}{(A+B)(B+C)(C+A)}.$$

If ABC is an equilateral triangle this

$$\text{ratio}=2\cdot\frac{1\cdot 1\cdot 1}{2\cdot 2\cdot 2}=\frac{1}{4};$$

if a $90°$-$60°$-$30°$ triangle the

$$\text{ratio}=2\cdot\frac{3\cdot 2\cdot 1}{5\cdot 4\cdot 3}=\frac{1}{5}.$$

It is worth noting at this stage that if the sides of ABC are divided at D', E', and F', in the *direct ratio* of the *adjacent angles* the area of the triangle $D'E'F'$ will be found given by the same expres-

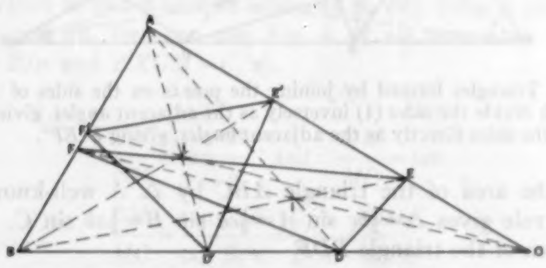

FIG. 12. Triangles formed by joining the points on the sides of the triangle ABC which divide the *sides* (1) inversely as the adjacent *sides*, giving DEF and and (2) divide the *sides* directly as the adjacent sides giving D', E', F'.

sion as above and Ceva's Theorem also shows that AD′, BE′, CF′ are concurrent (See Fig. 11).

Also if the sides of the triangle ABC are divided at D, E, F, *inversely* as the *adjacent sides* (Fig. 12) it is easy to show that AD, BE, CF are concurrent and that the area of the triangle DEF is found similarly to the treatment above to be given by

$$\frac{\text{Area of }\Delta DEF}{\text{Area of }\Delta ABC}=\frac{2abc}{(a+b)(b+c)(c+a)}$$

If the sides of the triangle ABC are divided at D', E', F' in the *direct* ratio of the *adjacent sides*, AD', BE', CF' are concurrent and the area of $\Delta D'E'F'$ = area of ΔDEF. With a 3-4-5 triangle this

$$\text{area ratio}=2\times\frac{3\times4\times5}{7\times9\times8}=\frac{5}{21}\cdot$$

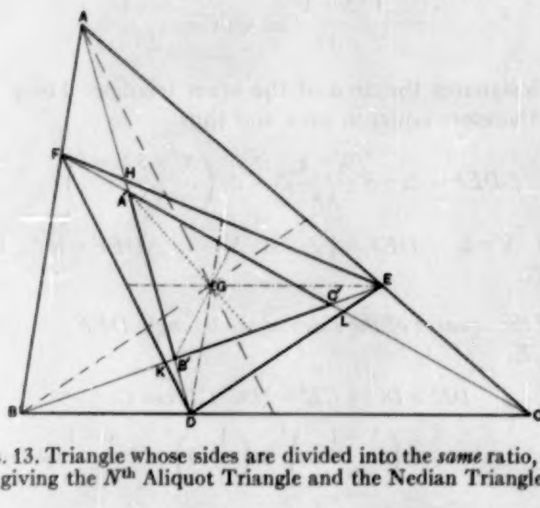

FIG. 13. Triangle whose sides are divided into the *same* ratio, thus giving the N^{th} Aliquot Triangle and the Nedian Triangle.

In both Fig. 11 and Fig. 12 the centroids of the Δs ABC, DEF, $D'E'F'$ are collinear, with the centroid of ΔABC as the midpoint.

Triangles formed by dividing the three sides of the main triangle in the same ratio and in order and joining the division points.

In Fig. 13 the sides BC, CA, AB of the triangle ABC are divided at D, E, F such that

$$\frac{BD}{BC}=\frac{CE}{CA}=\frac{AF}{AD}=\frac{1}{N}$$

In Fig. 13 the value of N has been taken as 3.

The triangle DEF may be called the "Nth point-division Triangle." It has the same centroid as the main triangle ABC. This is evident by the concurrence of the medians of the two triangles. It is proved easily by remembering that the center of gravity of a triangle is at the same place as the center of gravity of three equal masses placed at the vertices of the triangle and applying the theorem of moments.

The area of the triangle DEF

This$= \triangle ABC - \triangle BDF - \triangle CED - \triangle AFE.$

Each of these last three triangles has two sides and an included angle known. The area of

$$\triangle DCE = \frac{1}{2}\left(\frac{N-1}{N}a\right)\left(\frac{1}{N}b\right)\sin C$$

$$= \frac{1}{2}\,\frac{N-1}{N^2}\cdot ab\sin C = \frac{N-1}{N^2}\triangle$$

where $\triangle$ designates the area of the main triangle. These three triangles are therefore equal in area and thus

$$\triangle DEF = \triangle - 3\,\frac{N-1}{N^2}\triangle = \triangle\left(\frac{N^2-3N+3}{N^2}\right)$$

Note. If $N=2$, $\triangle DEF = \frac{1}{4}\triangle$; if $N=3$, $\triangle DEF = \frac{1}{3}\triangle$; if $N=\infty$, $\triangle DEF = \triangle$.

The sum of the squares of the sides of the triangle DEF

In $\triangle DCE$,

$$DE^2 = DC^2 + CE^2 - 2DC\cdot CE\cos C$$

$$= \left(\frac{N-1}{N}a\right)^2 + \left(\frac{1}{N}b\right)^2 - 2\,\frac{N-1}{N^2}\,ab\cos C$$

$$\therefore DE^2 + EF^2 + FD^2 = \frac{1}{N^2}\left\{(a^2+b^2+c^2)((N-1)^2+1)\right.$$

$$\left. -2(N-1)(ab\cos C + bc\cos A + ca\cos B)\right\}$$

But $c^2 = a^2+b^2-2ab\cos C$ with two other similar equations. $\therefore$ by addition $a^2+b^2+c^2 = 2(ab\cos C + bc\cos A + ca\cos B)$. Hence

$$DE^2 + EF^2 + FD^2 = \frac{1}{N^2}\left\{(a^2+b^2+c^2)(N^2-2N+2-N+1)\right\}$$

$$= \frac{1}{N^2}(a^2+b^2+c^2)(N^2-3N+3)$$

We see that $(DE^2+EF^2+FD^2)$ is the same fraction of $(a^2+b^2+c^2)$ as the area of $\triangle DEF$ is of the main triangle ABC—an interesting result.

Note. If $N=2$, $DE^2+EF^2+FD^2=\frac{1}{4}(a^2+b^2+c^2)$ which is otherwise obvious.

The Nedians and the Nedian Triangle

Join AD, BE, CF. These lines are the Nedians* and the triangle $A'B'C'$ contained within them is the Nedian Triangle.

We saw in our earlier accounts that

(1) the sum of the squares of

$$A'B',\ B'C',\ C'A'=\frac{N^2-N+1}{N^2}(a^2+b^2+c^2)$$

(2) the area of the

$$\triangle A'B'C'=\frac{(N-2)^2}{N^2-N+1}(\triangle ABC)$$

(3) the centroid of the Nedian Triangle $A'B'C'$ is coincident with the centroid of the Triangle ABC. This is evident also from the concurrence of the medians of these triangles as seen in Fig. 13.

Thus the triangles ABC, DEF, $A'B'C'$ have a common centroid. It has also been shown† that the nedians divide one another in equal ratio, i.e. that

$$AA':A'B':B'D=BB':B'C':C'E=CC':C'A':A'F=N:N(N-2):1$$

Measurements of the ratios in which EF, FD, DE in Fig. 13 are divided at H, K, L by the nedians AD, BE, CF indicate that $A'B'C'$ is a backward nedian triangle of $\triangle DEF$. $N=3$ as the first ratio of Fig. 13 appears to lead to 5 as the second ratio, i.e.

$$\frac{FH}{FE}=\frac{DK}{DF}=\frac{EL}{ED}=\frac{1}{5}.$$

Another diagram in which $N=4$ in the first ratio appears to lead to 10 as the second ratio. Further analyses shows that if M is the second ratio, $(M-1)=(N-1)^2$.

The results I have given above of some interesting published work on the geometry of triangles plus a few additions of my own will, I hope, provoke many of our younger Geometers to push on further.

* *The Mathematics Teacher*, Vol. XLIV, p. 46, Vol. XLV, p. 603. Also *The Mathematical Gazette* (England). Vol. 38, May 1954.

† See Mathematical Snack Bar by N. Alliston Heffer, Cambridge, England, 1936, p. 12.

JOHN E. POTZGER

1886–1955

The Central Association of Mathematics and Science Teachers held its annual meeting in Indianapolis in 1934. At that time members of the Association here invited Dr. John E. Potzger to join the organization and accept the chairmanship of one of the local committees. This he did. He immediately became an enthusiastic member and continued to serve the organization until his untimely death on Sunday, September 18, 1955.

He served as president of the Central Association in 1948, as vice-president in 1947, and was a member of the Board in 1945–46. He also served on many committees and was chairman of the Business Committee for the Anniversary Publication. The night before his fatal attack he talked about his plans to attend the Detroit meeting this year.

Dr. Potzger was recognized internationally as a scientist in paleobotany. Becoming a professor of botany at Bulter in 1931, he was named head of that department three years ago. In 1949 he was awarded the J. I. Holcomb award for making the largest contribution to Butler University in the field of education during that year.

Dr. Potzger was born in Presque Isle County, Michigan in 1886 and came to Indianapolis as a young man to teach at the Emmaus Lutheran School, where he was on the faculty for 24 years. He became interested in Science while taking advanced training at Bulter University and received his master's degree from Butler and his PhD. from Indiana University in botany. Entering the field of scientific research rather late in life, he always seemed to be hurrying to make up for the years he had spent in other work. I only know of one short vacation which he has taken in many years.

His research concerned changes in climate and forests in Eastern North America since the retreat of the continental ice sheets has extended over a period of 22 years. These studies of the post-glacial period proved that Canadian Spruce once covered the eastern North America area. For the past four summers he had gone to Canada to the Tremblant Biological Station in Quebec to conduct studies in forest history.

He was a member of the American Institute of Biological Sciences and the immediate past president of the Ecological Society of America. He was a member of Phi Kappa Phi and of Sigma Xi.

The son and brother of Lutheran ministers, he was himself an ardent church worker. Last year he was chairman of a drive to raise money to build a new church school.

I have known John Potzger since he was best man at my sister's wedding many years ago. I have never known a more earnest student, a finer Christian, a more loyal friend!

MARIE S. WILCOX

A MEMORIAL SCHOLARSHIP

A Memorial Scholarship in Botany is being established at Butler University in memory of the late Head of the Botany Department and Past President of The Central Association of Science and Mathematics Teachers and of the Ecological Society of America, Dr. John E. Potzger. Persons wishing to make donations should send checks to the Botany Department, Butler University, Indianapolis 8, Indiana, made payable to the J. E. Potzger Memorial Scholarship Fund.

This is an opportunity for members of the Central Association of Science and Mathematics Teachers to contribute to a cause in honor of our late Past President of '48 and our Editor for Biology from January 1941 to May 1954. Dr. Potzger could always be relied upon, either as an editor or as an active member of CASMT.

—GLEN W. WARNER, *Editor*

BUCKNELL DEDICATES NEW SCIENCE BUILDING

"It seems absurd to trust the administration of a modern state to men ignorant of science and its consequences to society," declared Dr. John C. Warner, president of the Carnegie Institute of Technology, in an address at Bucknell University today.

"Neither should we trust the administration of a governmental unit or a business to a scientist or engineer who is ignorant of the humanities", said Dr. Warner, who spoke at the dedication of Bucknell's new F. W. Olin Science Building, gift of the Olin Foundation.

Dr. Warner told his audience that lack of appreciation for the methods and accomplishments of science on the part of our leaders is responsible in a considerable degree for the material maladjustment and lack of moral aspiration in modern society.

"Not having solved the problems of equatably distributing the material benefits of science, we waste them in trade wars, class strife, and armed conflict," he explained.

He expressed the conviction that use of the scientific method, in modified form, could help solve many of our current social, political, and economic problems.

"We need to educate political, moral, and business leaders who are more scientific and scientific leaders who are more humane," he concluded.

Formal presentation of the building to the University by Dr. Charles L. Horn of Minneapolis, president of the Foundation, highlighted the ceremony attended by more than 2,000 students, teachers, and invited guests.

Dr. William H. Coleman, vice president and dean of the college, accpeted the building which contains a memorial plaque dedicating the structure "to the advancement of science and to the preparation of youth for service in the world of tomorrow."

IS HOMEWORK ONE ANSWER?

JOHN D. WOOLEVER
Mumford High School, Detroit, Michigan

Recently it has been demonstrated that the greatest drop in science interest and enrollment occurred after Junior high school and the reduction in class enrollment was most obvious in the Chemistry and Physics classes. This might occur in the Biology classes were it not for the fact that many school systems require the students to take one science for graduation and most would rather take Biology than the other two sciences. What keeps so many students from electing Chemistry and Physics? There is not a single answer to this question apparently and as a result we must attack our problem from every angle.

Ignorance of opportunity, lack of enthusiasm and many other factors enter into the picture. But let us not rule out propaganda. When it comes to selecting an elective course, the counselor, overloaded with students may not be very convincing and as a result our prospective scientist seeks advice from his friend. His friend tells him of his own experiences, or what he has heard from other students. He sees what his friend does outside of the lab, the time required, and there is no secret about whether or not there is joy in taking Chemistry and Physics.

Undoubtedly there are some students in these classes who should not be there because they do not have the ability to comprehend the subject to begin with, and therefore should have been directed to what some might call the "General" courses. These students say science is too tough. Some are taking the course under protest, having already decided their careers but are being coerced into taking the class by counselors for graduation requirements. These call science boring. Both of these students have a great influence on the unsuspecting student who wonders whether he should take a science course or not.

Another student who wanted to take a science and is now disappointed in what he is doing there could be a good salesman and direct some business toward the science department but there are some things he doesn't like about it. One thing is the homework. In a five year survey of the attitudes of students toward science and scientists, the author found homework high on the objection list. Beyond the attitude of disliking homework in general, the primary objection is the KIND of homework. It appears to be monotonous. They like the laboratory work and the demonstrations in class. Most of them

like the challenge of an interesting problem, but after class . . . the interest is stifled. It primarily reverts back to the apple problems of early arithmetic classes.

Apparently most of the textbook authors have lost sight of why elementary and Junior high school students like Science. Comparing General Science with Chemistry and Physics texts, there is an outstanding difference. Viz: the encouragement of activity by the student, at home, with simple home equipment.

Quite often the only connection between lab work and homework seen by the student is the mathematics, the computation of anticipated results. It has long been a complaint of business men, teachers and parents alike that in spite of how well many students do in school, they frequently do not associate the things they do with what happens at home in their daily activities. Homework certainly doesn't solve this problem, but it could help.

Fortunately the Elementary science teacher uses little catalogue type laboratory equipment. Unfortunately the High School teacher forgets how effective this technique is. It could be used effectively by assigning the high school student some experiments to do at home with equipment he has at home and it would give him an opportunity to do what he enjoys most.

There are many home type experiment books on the market and the Elementary science books can suggest hundreds more. Science education journals devote much space to "Here's How I Do It" teacher demonstrations. With a little ingenuity on the part of the teacher, he can turn many of these into "Here's How They Can Do It" homework experiments.

To be most effective, there are a few major points to be considered before using these home equipment experiments. Viz:

1. The experiment should revolve about the material studied in class or contemplated for the next meeting.
2. Each experiment should be short and as simple as possible.
3. No dangerous chemicals or high voltage should be required.
4. There should be a connection with the math problems or other assigned homework.
5. The technical measurements should be held to a minimum.
6. Give the student a choice of several he may perform. In addition to a psychological effect, it opens the door to those who wish to go beyond the required assignment. These students are the ones we should encourage to choose science as a career.

Although the use of elementary science experiments as homework may appear a bit juvenile to some teachers, we should not be above using any technique, no matter how simple, to achieve the objectives of science education and encourage others to enter scientific occupa-

tions. Experience is still a good teacher and the more opportunities we give the student to experience scientific phenomena the better chance he has of learning something. We must also not lose sight of the fact that in addition to helping the student in this method, some of his enjoyment and enthusiasm is bound to rub off on his friends who might otherwise pass up the science department and a science career.

INTERNATIONAL FRIENDSHIP LEAGUE

School boys and girls who have made pen friends in other countries, and have exchanged information of a personal and first-hand nature, pictures and other souvenirs, have improved in their work in geography, history, civics, letter writing and other subjects, thousands of teachers have written. Often they bring their interesting letters from overseas to class with pride and have read their letters aloud to other members of the classroom for discussion. The idea that some personal friend in a far off country writes about the things of interest to them, never losses its fascination. The International Friendship League of 40 Mount Vernon Street, Boston, Massachusetts, is in constant communications with schools in one hundred and thirty-seven free countries and territories of the world. These world-wide schools send the names, ages and addresses of boys and girls interested in making friends by mail with young people of their same ages and interests in all parts of the United States. The two-way exchange of information, mostly done in English, is an educational project of inestimable value.

The following is a letter written by President Dwight D. Eisenhower to the International Friendship League:

"I am happy to extend my best wishes to those who by means of the International Friendship League stimulate good will, human understanding and the true spirit of brotherhood among all the peoples of this divided world. Few undertakings can more realistically attack the roots of our international discord and suspicion; few offer better prospects, over the years, of building more enduring world ties. To all who engage in this fine enterprise I send my compliments, with the hope that ever-growing success and achievement will crown these valued efforts.

Sincerely,
(SIGNED) DWIGHT D. EISENHOWER"

Any teachers who are interested in bringing the opportunity of making personal pen friendships around the world before their students are invited by the League to send a self-addressed, stamped envelope requesting a free supply of descriptive brochures to:

International Friendship League
40 Mount Vernon Street
Boston 8, Massachusetts

WHAT'S HAPPENING IN THE SCHOOLS IN YOUR COMMUNITY?

The school problem is a state-local one—it cannot be solved in Washington And so, while the nation-wide picture is important . . . The best "statistics" are those for your own school district

If you are interested in the children of your community, look to your own school district.

TEST-SCORING CAN BE EASIER

Eldon Hauck
Anaheim City School District, Anaheim, Calif.

TEACHERS! How many times have you looked at a stack of test papers awaiting your marking pencil? While looking, how often have you been assailed with countless thoughts which might prove adverse to a purely professional attitude? Eventually, you'll have buckled down and doggedly completed your task.

There is a better way to set up your test for scoring. One that holds less drudgery. One that actually holds an element of pleasure by allowing you to correct the same number of papers in a fraction of the original time.

All you have to do is arrange your test with a *horizontal answer row* instead of a vertical answer column.

Make up your own test or adapt one you wish to use. The ease of correcting lies in the use of a sentence, phrase, or word sequence having the same number of letters as there are problems.

It will take more time to make up the first test, but use of the method will shorten the construction time and decrease the correcting time by as much as ninety per cent.

Use is restricted to tests of the multiple choice and matching variety.

Caution must be exercised in making up the phrase. Simplicity might allow students to complete the test without actually working any problems. There should be only one correct answer to each question. Although any procedure could be used the following has been found most convenient.

Let's assume that the test will contain 25 problems. Construct an answer phrase, word or number sequence of 25 letters or digits. Now construct the test.

The example test (p. 709) was given to seventh grade classes. The answer phrase for the 25 problems is: "THIS PROOF LIES IN THE PUDDING," which for a perfect paper would appear in the answer row's parenthesis as:

T H I S P R O O F L I E S I N T H E P U D D I N G.

For those of you who may be doubtful, let's question its practicability on the basis of its merits. Before commencing our argument let's dwell upon one basic fact!

Every printed word of those languages with which we are most familiar is actually printed in horizontal rows! We have been taught, have learned, and teach others to read these printed words *in a horizontal row, from left to right!* Does it stand to reason that our practiced eye

can devour a series of letters or numbers placed in accord on a horizontal row more quickly and easier than those same letters or numbers placed in a vertical column? Our foremost educators agree with this!

Is it more difficult for the student to place his answers in logical sequence in a horizontal row at the top of the paper rather than a vertical column to the left side? Allow your students to decide this question for you!

Would it be possible for students to *piece-together* or supply the missing letters for answers they do not know or cannot arrive at? This would depend entirely upon the person making up and administering the test, would it not? Simple phrasing and simple construction combined with a high intellect might tend to contribute toward this end, but it is possible to keep the answer phrasing well above the grade level of your students; and the number of choices on each item can be increased.

In the sample test it may be noted that the selection of letters used in the answers runs through vowels and consonants and that several words may be made from the same series of letters through any number of problems. Equal spacing of letters in the answer row also tends to discourage such practice on the part of the students. Keeping the initial fact in mind, it stands to reason that the use of the conventional A, B, C, or 1, 2, 3, throughout the test would facilitate correction if answers were placed in the *horizontal row*.

The use of a series of words or a phrase, being easier to commit to memory, simply facilitates correcting the papers.

Another critical attack might be from the standpoint that there is not enough space on the paper for working the problems. Such an omission would eliminate any record for the checking of problems for error on those answers missed. The teacher certainly is not limited to the number of sheets comprising the test, nor is the student immune to handing in his computations. Such would apply only in the case of solving mathematical problems. In the multiple choice or matching type test where answers are dependent upon a store of knowledge and not on computation it would be unnecessary.

Probably the best argument in favor of the method rests in its use over the better part of the year. During this time the original was improved upon to a great extent. It was found to save time, a great deal of time, in the correcting of papers. It contains an element of fun in the correcting of papers and in making up the test. The instructions were not difficult for the student's understanding. Students picked it up immediately. Among the 156 students who regularly participated there was no noticeable fluctuation of ability place-

ment through the use of this type test. The group's IQ range was from 84 to 146.

"DECIMALS"

NAME ______________

ANSWERS:

(____)	(____)	(____)	(____)	(____)	(____)	(____)	(____)	(____)	(____)
1	2	3	4	5	6	7	8	9	10
(____)	(____)	(____)	(____)	(____)	(____)	(____)	(____)	(____)	(____)
11	10	13	14	15	16	17	18	19	20
(____)	(____)	(____)	(____)	(____)					
21	22	23	24	25					

INSTRUCTIONS: CIRCLE THE CORRECT ANSWER OF EACH PROBLEM and then: Place the letter for the correct answer of each problem above that problem's number in the "ANSWERS" row. USE CAPITAL LETTERS. Work the problems on the paper provided with this test. When finished bring your work and this paper to the desk.

ADD

1. .32 plus .09 plus .27 plus .16 equals: M—.83; T—.84; X—8.4!
2. 8.603+2.950+6.087=H—17.64; A—17.62; O—1.764!
3. 14.2+26.3+38.9+40.6 equals: B—119.8; D—1200; I—120!

SUBTRACT

4. $.89 from $5 leaves: D—$4.19; N—$4.21; S—4.11!
5. Twenty dollars less $16.95 equals: A—$3.50; P—$3.05; O—$4.05!
6. Fifty dollars minus $29.75 is: O—$19.25; R—$20.25; H—$21.25!
7. $168.55 subtracted from $200 would leave: A—$32.45; E—$31.35; O—$31.45!

MULTIPLY

8. .78×.25=O—.195; V—1.95; D—.196!
9. .008×46=E—.378; F—.368; S—.366!
10. .9×.32=L—.288; N—.278; T—.0278!
11. .09×.08=A—.72; I—.0072; H—.072!
12. .07×2.06=E—.1442; O=.1432; N—.1342!
13. 24×3.05=U—7.32; T—7.22; S—73.2!
14. 6×.095 equals: G—.075; I—.57; H—.057!
15. .012 of 62.9 is: A—.7547; N—.7548; L—.7558!
16. .004 of .23=T—.00092; A—.0092; U—.00082!

DIVIDE

17. 9).45 H—.05; T—.5; S—5!
18. 2.5).0075 H—.03; E—.003; T—.0003!
19. .13).052 U—.04; I—4; P—.4!
20. 1.2).96 U—.8; H—.08; S—8!
21. 1.8)540 A—.3; D—300; T—30!
22. .011)8.8 D—800; E—80; H—8000!
23. .14)28 F—.2; I—200; S—20!
24. .15)90 T—60; N—600; A—6000!
25. .16).0256 G—.16; S—.017; H—1.6!

This method of test scoring does away with the conventional scoring key thereby saving time and eliminating excessive handling.

The time-saving value is not fully realized until the papers are in. Then you'll be amazed at the ease and speed with which they are corrected. By having the students bring their completed papers to your desk, you'll find it possible to return a paper (graded) to its owner before he has moved more than three paces away from your desk. Of course, the number of paces will vary according to the number of incorrect answers per paper. You'll return some before the student has recovered his extended hand! In such an instance, that student's registered facial expression will more than pay you for having made the effort of getting out of bed that morning.

HIGH SCHOOL INCOME TAX COURSE

The Internal Revenue Service is making available to each school, upon request, sets of tax instruction materials designed for use in the classroom. Included in the set are teachers' discussion guides and student handbooks showing several typical tax situations found at different income levels; sample tax forms which may be used for working out tax problems and enlarged copies of forms for bulletin and blackboard use. In addition, there is a special section devoted to the special tax problems of farm income.

Distribution of these tax kits, which will be available by December 1, 1955, wi l be coordinated this year by District Directors of Internal Revenue. They are in contact with school officials in their jurisdictions, providing superintendents, principals and teachers with order blanks and information concerning the filling of these orders.

Educators interested in these tax teaching aids may contact their local Directors of Internal Revenue, who will be able to furnish them the necessary information about the course. Or the kits may be ordered from the Public Information Division, Internal Revenue Service, Washington 25, D. C.

BLACK COBRA OLDEST LIVING SNAKE IN U. S.

A black cobra from Africa holds title as the oldest living snake in United States zoos, reports Dr. C. P. Perkins of the San Diego Zoo in his yearly old-age snake census.

The deadly poisonous cobra (Naja melanoleuca), housed at the zoo here, is 26 years and 10 months old now. If he holds out for 14 more months, he will tie with a 17-foot anaconda from the Washington Zoo for the all-time old age championship. The Washington Zoo's big snake was 28 years old when it died. This is thought to be the record age for captive snakes in this country.

The cobra still has a short way to go before he rates second place in the all-time race. This record is held by a rainbow boa (Epicrates cenchria) at the Bronx Zoo, that scored up 27 years and four months before dying.

Second oldest living snake in captivity in the U. S. now is a large gopher snake (Drymarchon corais) from the American west, with 22 years and eleven months. A dangerous spitting cobra (Naja nigricollis) housed at the Brookfield Zoo, takes third place with 20 years and 9 months.

According to Dr. Perkins' census, the oldest captive rattlesnake is a western diamond rattler (Crotalus atrox), at the San Diego Zoo, 19 years and 2 months old.

PICK THE RIGHT JOB

George E. F. Brewer
Marygrove College, Detroit 21, Michigan

When I was young and went to school, I received a lot of good advice. I just can't understand why nobody told me that I will have only $\frac{1}{4}$ of my waking hours for my family, the house and the fun I want to get. What I am driving at, is this: Unless a person finds a type of work that he loves, he is just unhappy for $\frac{3}{4}$ of his day. Worse than this, unless somebody likes his work, he just can not make headway against the competition.

I was very lucky, I picked something which I liked and still love to do: Chemistry.

How do you get to be a "chemist"? You study it in college. Most colleges offer at least 4 courses in chemistry (one course per year) and one or more elective courses.

Four college students of chemistry are going to explain to you what these 4 basic chemistry courses offer.

Maybe you will like the idea and study to be a Chemist.

GENERAL CHEMISTRY

By Nancy J. Primeau

College freshmen take General Chemistry, a course designed to lay the foundation for the more advanced work which is to follow. The goal of the course is the understanding of the basic principles of chemistry. I suppose that you know that all substances are composed of invisibly small units, called atoms, and we know about one hundred different kinds. A number of atoms can get together in a sort of a cluster, to form what we call a molecule and we know about 1,000,000 different kinds. We also know that we can put together—or as we say "synthesize"—many more millions of different molecules for any desired special purpose. In fact, all the new fibers, like nylon, plastics, drugs, and so on, are new kinds of molecules which chemists designed and built.

To give an example of how "General Chemistry" operates let's put this question: Why do we believe that atoms exist? Well, let's carry out an experiment. We weigh 24 parts of a metal called magnesium and place it under water (at A in the picture). Then we weigh 65 parts of another metal called zinc and place it at B. Mind you, it does not matter how large the unit part is, but if you use 24 lbs. of one you have to use 65 lbs. of the other. I used 0.24 gram and 0.65 gram. When these metal chips are in place, I fill a glass cylinder with water, cover it with a glass slide, and turn it upside down without spilling a drop, or an air bubble getting into it. I practiced that. That's one of

many tricks to handle lab. equipment that I have learned. Then I add a little hydrochloric acid through a long stemmed glass funnel. The acid dissolves the metal. It just disappears in the water, giving off a fizz, that is a "gas" which rises to the top of the glass cylinder. We call this gas hydrogen. Now you just think that over; barring black magic, there is only one explanation: The gaseous substance must have been part of the acid and the metal must have taken its

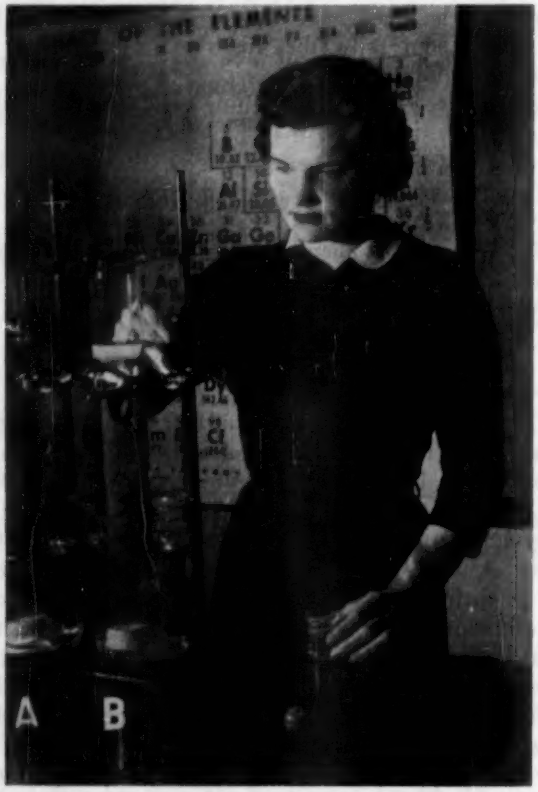

FIG. 1. Determination of the combining weights of elements.

place. It's like this: metal plus hydrogen chloride gives hydrogen plus metal chloride. Now please notice that the 24 units of magnesium gave exactly as much gas as 65 units of zinc did. When you think that over, you come up with the thought that an atom of magnesium must weigh 24/65 of what an atom of zinc weighs. Similar experiments with other chemical elements were carried out during the last century by a large number of scientists all over the world and their findings were

compiled in the so called "periodic chart of the elements." I am not sure that I have brought my point across. It took a whole week of lectures, experiments, assignments, and quizzes before I understood it as far as I do. You see, college instruction has centuries of experience in teaching these things and in arousing your interest, which helps a lot in getting the many ideas on which chemistry is based.

ANALYTICAL CHEMISTRY

By Jean M. Craig

College Sophomores can register for a course in analytical chemistry.

What is "analytical chemistry"?

You may have noticed that boxes of candy have printed in one corner: "Made from sugar, corn starch, syrup, albumin, . . . " This is really a *qualitative analysis* of the candy. Now you just try and make the candy! You would have to know the quantity of ingredients, like 4 oz. of sugar, 1 oz. of corn starch, and so on. Such a recipe would be called a "quantitative analysis."

The goal of the course in *qualitative analysis* is to determine the composition of any metal ("alloy") and of any mixture of salts. Towards the end of the semester you are given a chunk of metal. You do your analysis and report to the instructor. It's amazing, but eight out of ten in my class had the answer right at the first try!

Now how did we go about it? First we had to "dissolve" the metal. Most metals dissolve in acids. My "unknown metal" did not do that, but they had taught us a lot of other tricks, so I finally got it into solution. Then we had learned how to add various chemicals which "precipitate" certain specific metals. A precipitate is a deposit at the bottom of a liquid (like the scale at the bottom of a tea kettle).

We learned a lot about precipitates. For instance: You dissolve in water any substance, found no matter where in the universe, then add ammonia and a chemical called "dimethyl glyoxime." If a beautifully pink precipitate forms, then you know that the "unknown" must have contained nickel. The appearance of the pink precipitate proves it, or as we chemists say, is a "test" for nickel.

During the course in qualitative analysis we learned to test for about 30 metallic elements and for about 15 different acids. Of course, we had to know the theory behind these tests and that involves some simple algebra.

I am fascinated by what I learned: The manual skill in the laboratory; the ability to find out the chemical nature of almost any substance; best of all, give me any chemical equation involving salts, an equation that neither I, nor anybody else has ever seen and ask me,

"Is it possible that this reaction will take place in a test tube?" Then I will go to my books or a library and—using a little mathematics—I will give you the answer.

How are quantitative analyses made?

Let's return to the pink precipitate which we used in qualitative analysis as proof of the presence of nickel. The same precipitate can be used in quantitative analysis for nickel. We "catch" the precipitate on a "filter paper," which is really an extremely fine sieve. Then

FIG. 2. Performance and analysis of an electroplating bath.

we dry the precipitate and weigh it. One-fifth the weight of the precipitate is nickel, $\frac{4}{5}$ of it is the dimethylglyoxime. Suppose we started with 1.000 gram of unknown and found 1.500 gram nickel-dimethylglyoxime. One fifth of 1.500 is 0.300 gram nickel or 30.0% of the unknown. Since we came up with our result from the weight (gravity) of the precipitate, this technique is called gravimetric anal-

ysis. It gives very good results but it is time consuming. A faster, more modern way of analysis is called "volumetric" analysis. Here the final result is computed from the volume of reagent solution which has to be added to the solution of an unknown. Instead of spending hours for a gravimetric analysis, the answer for a volumetric analysis is reached in minutes. There are still more modern methods of analysis and many of them are taught in the course of analytical chemistry.

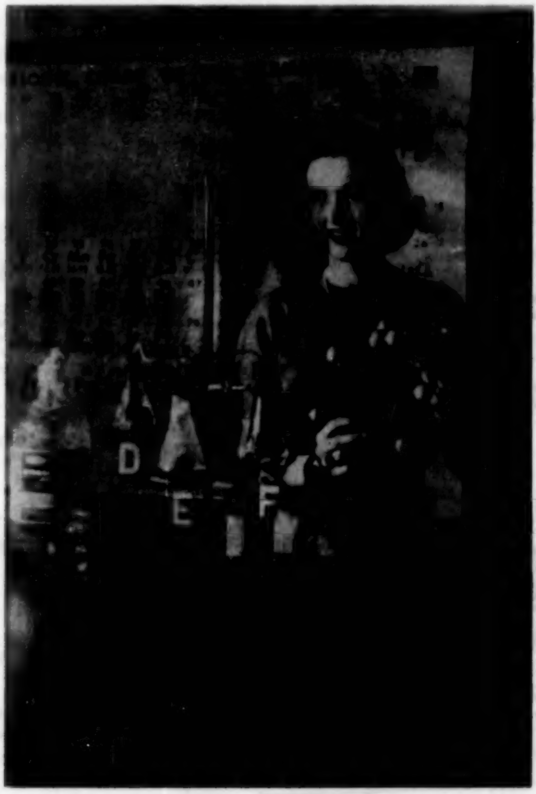

FIG. 3. Preparation of aniline hydrochloride.

Now you may well be asking, "Just what is the use of all this knowledge?" well, it prepares me to hold a nice job in the laboratory of an electroplating plant, while I am still in college.

To demonstrate the importance of chemical analysis, I brought from the place where I work a sample of a nickel plating solution—we call it "bath"—which works perfectly well (at *C* in the picture) and a sample of a bath which would ruin a lot of automobile bumpers,

if chemical analysis were not applied to predict that this bath is unfit for use.

In general, whenever a new product is made, or when materials are bought or sold, somewhere along the line, chemical analyses or syntheses have to be made.

ORGANIC CHEMISTRY

By Constance L. Burden

Another of the College Chemistry courses is Organic Chemistry, which is really the study of the element "carbon." Carbon is so important, because everything that is connected with "life" contains carbon. Carbon is also one of the constituents of drugs, fuels and so on. The goal of the course is threefold: to learn the system of naming

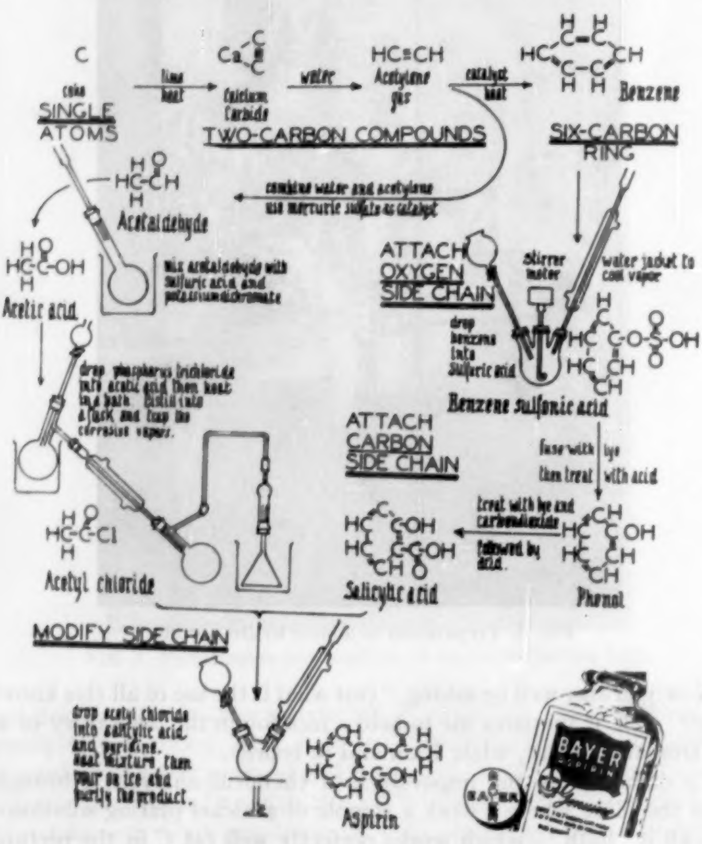

FIG. 4. Synthesis of aspirin.

organic compounds, to learn the types of chemical reactions which carbon compounds undergo and to learn the practical conditions under which these reactions take place.

I hold in my right hand the model of a molecule: 6 carbons, 7 hydrogens and 1 nitrogen. The carbons form a ring. On paper we write $C_6H_5NH_2$. I learned that this substance is called aniline and from what I learned in General Chemistry I know that a substance of this type will chemically combine with hydrochloric acid to give a salt (looking like table salt). Actually when I mix hydrochloric acid and aniline I get a sort of a slush. The white salt, called anilinhydrochloride, is in that slush all right, but it is hard to separate it from impurities. It takes a set of flasks to make the compound in pure form. We put hydrochloric acid into the first flask (D) and heat it, so that dry hydrochloric acid gas gets into the second flask (E) in which we have aniline. The third flask (F) serves as a trap for unreacted corrosive vapors. This experiment gives you an idea why chemists use all sorts of queer shaped equipment, just to make chemical reactions go the way they want them to go.

Here is a chart, Fig. 4, showing the making of aspirin and the laboratory equipment which we used to make it. All synthetic compounds are made following certain patterns: make atoms join each other, attach side chains, modify them and purify the product.

PHYSICAL CHEMISTRY

By Nettie H. Harris

Physical Chemistry is the study of the inter-relationship of physical and chemical phenomena. "Heat," for instance, is something which the physicists study. The heat (or more general "energy") given off during chemical reaction is something in which both chemists and physicists are interested and we learn about such phenomena in a course called Physical Chemistry. This two semester course deals with about 20 different topics, such as "gas pressure," "electricity from chemical reactions" (like those taking place in a flashlight battery) and so on. Facts are given and worked with in the lab. so that molecules, atoms, electrons, and so on become reality, rather than "possible explanations." Most topics in physical chemistry have far reaching implications in natural philosophy, or they open an outlook into entirely different approaches in science. Let me give an example: "Detergents" are new chemicals known to all of us. Many chemists work in this field. One of the properties of all detergents is to make water wetter, I mean, more penetrating. To demonstrate this, I take 2 sheets of wrapping paper and make a cone out of each. Then I place each cone in a glass funnel and fill the cones with water. As you see, no water drips through (G). Now I add to the other funnel

a few drops of shampoo and the water is now so "wet" that it just streams through the paper (H). It took a lot of scientists a long time to learn how to measure this "wetness." They measure the "surface tension" of liquids. You see there must be a force that holds a "drop" together or else it would break up into smaller units. The same force holds the water in the paper funnel and prevents it from flowing through. Several different methods and gadgets (J) for measuring the

FIG. 5. Demonstration and determination of surface tension.

surface tension are studied in the physical chemistry course. Then we go deeper into it: You know that all Chemistry is based on the idea that there are atoms and molecules. Many predications can be made from knowing the weights of these atoms (like how many tons of limestone it will take to get a ton of lime.) Now, of course, similar predictions can be made if we know the "size" of the atoms. While the weight of atoms does not vary, the volume which they occupy

depends to a certain extent upon the surface tension. Higher surface tension "crowds" them. Taking this into consideration, a table of "atomic volumes at unit surface tension" has been developed and it is used in many fields of Chemistry with success, where the table of "atomic weights" fails us. Indeed, to base Chemistry on the table of "atomic weights "is only one of many different approaches. During the course in physical chemistry you will learn several other such approaches.

WISCONSIN PLANS A NEW OBSERVATORY

A $200,000 gift which will bring major fulfillment of long-needed, modern astronomical facilities at the University of Wisconsin was accepted from the Wisconsin Alumni Research Foundation (WARF) by University regents.

The WARF funds will cover construction of a new 36-inch reflecting telescope, a main research observatory, and two adjacent buildings; and purchase of a 40-acre hilltop site somewhere within a 15 to 20 mile radius of the home campus at Madison.

The new telescope will provide five times the light-gathering power of the present 15-inch refracting 'scope which has served the greater part of a century as the major instrument at the UW's Washburn Observatory. The mirror for the new telescope was bought by the University several years ago and does not come within the plans for use of the WARF monies.

WARF's gift will permit Wisconsin to modernize and replace obsolescent equipment and provide tools for astronomical research equal to those available at other Midwestern universities, Prof. A. E. Whitford, director of Washburn Observatory, pointed out.

The astronomy department is now conducting a survey of suitable land, he indicated. The country station will have clearer skies, Wisconsin astronomers explain, avoiding the problems of city lights and industrial smoke which Washburn now contends with.

The two buildings to be constructed near the main research observatory will house a 12-inch reflecting 'scope for graduate student use and a heating plant and also will provide resident quarters for a graduate student caretaker.

It is hoped that the new facilities will be completed in time for the 80th anniversary of Washburn, which will take place in 1958. The venerable stone building atop Observatory Hill, center for astronomical study at the University, was constructed in 1878. It and the 15-inch telescope were the gift of Cadwallader C. Washburn, an early governor of Wisconsin.

There have been no major capital investments in astronomical buildings or instruments since then.

Headquarters for the astronomy department will remain on the campus at Madison, staff members said. They also said the planetarium, installed two years ago in the east wing of Journalism Hall, will also remain at its present site to serve primarily as a teaching aid for astronomy students.

BASIC FACTS

Our Schools need more money—what they get isn't enough

We are spending proportionately less of our income on schools today then we did in 1930—even then, the schools were supported inadequately

Education is an investment—good education means more jobs, greater production, better communities

THOSE TREE FARMS

B. Clifford Hendricks
457—24th Avenue, Longview, Washington

Lewis and Clark, with their fellow scouts, had crossed the continental divide. That hurdle was followed, almost immediately, by another. "Soon there was no trail. . . . Instead the unpenetrated gloomy forest, never yet blazed, rose over (them and) closed (its) ranks against the explorers. It drove their toiling defile, sometimes, even into the torrential rocky beds of the wild cold rivers . . . Down the western slope . . . they came . . . cutting a slow way . . . through the tamarack, fir, spruce and pine. . . (They were not lost but harrassed by) these forests, fed with rain-winds from the Pacific. Their great roots spread and twined and locked and treacherous moss overlaid them."[1]

Here we have white man's first impression of Bitterroot Mountain timber. They saw it not as tree-farms-to-be; for them these were tree-hinderers to exploration. The time lapse from that historic entry to the first concern for a "self-sustaining tree crop" was a century and one half. In that interval the northwest developed other sorts of tree resources.

Filbert Farming

In late October or early November northwest newspapers often contain news-ads. "John Helms has issued his annual call for filbert pickers. His thirty-four acre filbert farm is expected to yield twenty-five tons for the Thanksgiving and Christmas processing. Fifty to seventy-five pickers will be needed for this orchard. . . . Depending upon the number who report, the job is expected to require two weeks."

For plains people, filberts may be called hazel nuts that grow on trees. And those trees are much larger than over-sized shrubs. One tree, Oregon grown, is known to be eighty years old and has a spread of more than fifty feet. These trees invariably spread more than they spire.

Filberts are not picked directly from the trees. They are allowed to fall to the ground first. After the pick-up they are graded, washed, and dried to a moisture content of from eight to ten per cent. Marketing may be in the shell or as kernels only.

One feature of filbert culture that has required study by the specialists is its self-sterility. "The self-sterility of filbert varieties makes

[1] Peattie, Donald Culrose, "Forward the Nation," p. 237. G. P. Putnam's Sons, 210 Madison Avenue, New York 22, N. Y.

inter-planting necessary in order to provide for cross-pollenation . . . Varieties planted as pollenizers are in the orchard primarily to shed pollen. A crop of nuts on (them) is a matter of secondary importance"[2] The aim of the study is to find that particular pairing of varieties which will get a maximum of pollenation for the nut-producing member of the pair.

Filbert farming in the northwest has fostered the organization of cooperatives that greatly facilitate marketing the nuts. The economic promise in filbert farming has also prompted the initiation of a program of experiment station study of its culture.

Trees for Christmas

Filbert trees may be considered as contributing somewhat to Christmas cheer. A more conspicuous part of that season's program, though, falls to the Christmas tree. A few, or many, sprigs of berry-bearing holly also have a place among Christmas greens.

So there are Christmas tree farms. The timber-wise conservationists advise fitting the replant, for the forest cut-over land, to the soil. Their lowest classification, of cut-over terrain, is labelled Christmas tree land. It won't grow good forests, but it is desirable for Christmas trees since it barely supports life. "Trees there grow slowly . . . and become bushy and dense with uniformly spaced whorls of branches."[3] Such are *just the trees* for Christmas use. So, on such infertile soils, are the Christmas tree farms. Such a farm may spread over 20,000 acres where seedlings are watched, pruned, thinned and finally cut for shipment at holiday market time.

A Christmas tree farmer,[4] hear Tacoma, Washington, distributes four or five million trees a year and keeps several times that number growing. It is estimated that a total of thirty-one million Christmas trees are used each Yule-time season in America. The retail market gets about seventy-seven million dollars from that item in its Christmas sales.

Not all those trees come from Christmas tree farms, however, Good timber tree farm management requires thinning as the timber-producing replant, on the cut-over land, grows toward saw-mill size. If carefully planned, much of the cut-out, after the first five or more years of growth, can be sold on the Christmas tree market.

Holiday Holly

Christmas greenery, very commonly, also includes some sprigs of

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[2] Schuster, C. E., "Filberts," pp. 10–11. Extension Bulletin 628 (1944). Oregon State College, Corvallis, Oregon.

[3] Lunnum, Knut, "Raising Christmas Trees for Profit," p. 4. Pacific Northwest Cooperative Extension Publication 6, Washington, Oregon and Idaho Extension Services. Pullman, Washington.

[4] Worden, Wm. L., *Better Homes and Gardens*, December 1954, pp. 43 ff. Meridith Publishing Co., Des Moines, Iowa.

holly. While Christmas trees may come from almost any corner of America, holly is more localized in its production. Its chief American habitat is from British Columbia on the north to Crescent City, California, on the south and west of the Cascades. So the northwest has found its cultivation profitable and has given a proportionate share of experiment station study to its development. Oregon alone has issued a half dozen or more bulletins on various aspects of holly production.

Holly farms are mere garden plots when compared with the wide spreading acreages of Christmas tree farms. Holly plantings are listed in acres; Christmas tree farms are often rated in square miles. Even so the truck gardener has his place in the total picture as well as the 1000 acre wheat rancher with his combines.

Since holly is harvested as sprays, a single tree brings an income over a number of years. An ideal spray is rated: "Stems green or blue; leaves, uniformly distributed, deep green in color with flat mid-rib and ruffled spiny margins; berries, uniform in size, bright red in color, well distributed throughout the spray and do not shatter when ripe."[5]

Since the contrast of the red of the berries with the green of the leaf and stem is a major holly asset the production of berry-bearing holly becomes of first importance. This aspect of holly orcharding is, in a manner, like the filbert farmer's need for pollenizers. The holly, however, is not self-sterile but dioecious; that is, its male and female flowers are grown on separate plants. So holly farmers must make provision for pollenizers for their orchards if acceptable berry-bearing sprays are to be cut at market time. The number of male, pollenizing, trees needed in an orchard is appreciably fewer than on the filbert farms. Current practice calls for one male tree for every fifty berry-bearers.

It takes from six to ten years for a holly tree to yield a marketable spray. Time of cutting is determined by berry color and market demand. A hazard of off-season cutting is the loss by the dropping of the leaves and berries before the retailer can get the spray to the buyer. Proper timing and a sort of hormone treatment seeks to counter such loss.

In addition to nation-wide use of holly in sprays and wreathes, locally, many holly trees are used by landscape gardeners in park and resident plantings.

Timber Tree Farms

But the major publicity in the northwest is for timber tree farms. "The tree farming system is designed to perpetuate the industrial

[5] Roberts, A. H., and Boller, C. A., "Holly Production in Oregon," pp. 8–9. Bulletin 455. (Reprint 1953.) Agricultural Experiment Station, Corvallis, Oregon.

forests of America by maintaining a favorable ratio between the number of trees growing and the trees harvested."[6] The urge is a concern over industrial forests and the motive is, fundamentally, economic.

By a program of organized publicity and education owners of the forest lands are asked "to agree to protect their timber from fire, insects and disease; harvest according to a long-range plan and provide for natural or artificial reforesting of cut-over lands." Those who so agree are officially designated: tree farmers.

This movement, in the interests of economic conservation of our timber resources, was initiated in 1941 and has grown to a coverage of over five thousand farms with an aggregate acreage of some thirty-three million. It is nation-wide, in its membership, and a growing influence in efforts to conserve our natural resources. It is interesting to note that, though started by industrial organizations, in recent years an increasing percentage of applicants for its recognition are non-industrial forest owners.

The administration of the program of tree farm certification is provided by the Industrial Forestry Association. Admission to the tree farm status does not guarantee a permanant seat at its family table. The association maintains an inspection service which keeps it appraised of member compliance with the initial agreement. Failure to maintain that pledge usually loses that delinquent his membership listing on the association roster.

It takes about one hundred years to grow a saw-mill Douglas fir from the seed. However, not all those years are dead loss to the tree's owner. There are two or three income-bearing periods in that century. At the end of the first five or more years of growth the tree-lets are Christmas tree size. Thinning at that time may more than pay for itself by Christmas tree sales. When the new crop is forty or fifty years along another thinning improves growing space and this time brings income by sale of cuttings for wood pulp or poles. As the forest nears its optimum condition for market the trees are from one hundred and fifty to two hundred feet high and are ready for saw-mill cutting. It is at that time the tree farmer gets his major reward for his patience, diligence and industry.

While tree farming may get general approval for its stress of "away from timber mining; onward toward timber management"; even its most vocal salesmen concede its limitations. A local big timber company gave hearty publicity, recently, to its biggest fir. This one had a diameter of twelve feet two inches. That company's previous record breaker was only eleven feet in diameter. These exceptional trees

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[6] "Tree Farming in the Pacific Northwest," p. 4. Weyerhaeuser Timber Company, Tacoma, Washington.

were about seven hundred years old when cut. Obviously, no tree farmer is going to permit his trees to wait that long for harvest. Tree farmers will never produce such patriarchs of the forest.

Muir Woods

In 1945, world leaders working at San Francisco, on an international program for world amity adjourned briefly to Cathedral Grove in Muir Woods. It has not the "sustaining yield" nor the "over-ripe trees" or "trees long past their prime (for) harvesting" that rewarded that recess. Relief from the noise of the city in contrast with the sanctity of the thousand-year-old trees of Muir Woods hardly prompted thought of the economic during that visit. There, rather, they found that "oneness of the woods that has (an) impact of the human spirit. The natural feelings of (these) persons in (that) great virgin forest were awe and (uplift)"[7]

Joseph B. Strauss, builder of San Francisco's Golden Gate Bridge, has set it to meter:

"This is their temple, vaulted high,
And here we pause, with reverent eye,
With silent tongue and awe-struck soul,
For here we sense life's proper goal.

To be like these, straight, true and fine,
So make our world, like theirs, a shrine;
Sink down, Oh traveller, on your knees,
God stands before you in these trees."

Mrs. Crisler also adds, "Timber in a national forest is not a crop; it is a forest entity that can be wiped out in a few years and cannot be replaced in a thousand. A climax forest is . . . a biotic whole, fragile, living, a community. Its impact on the human spirit is a valuable experience."

Tree farm enthusiasts are explicit in their program. They are frankly concerned about industrial forests. Other values are incidental. They do give them marginal attention. However, those other values are not fully catalogued when only soil conservation and natural reproductive capacities of trees are listed. There are other not-to-be-overlooked assets, intangibles maybe, to which tree farmers as well as Mrs. Crisler should be sensitive. "Tree farming as proposed is good," she says. But its limitations need continued concern.

[7] Crisler, Lois, *Christian Century*, July 27, 1955, p. 867. Christain Century Foundation, 407 South Dearborn Street, Chicago 5, Ill.

Reversible lens for eight-millimeter movie cameras enables the user to take wide-angle or telephoto pictures, depending on which side of the lens is toward the camera. This unique lens is color corrected.

SCIENCE AND MATHEMATICS FOR TODAY'S YOUTH*

BRIGADIER GENERAL ARNO H. LUEHMAN, COMMANDER HQTRS
3500 USAF Recruiting Wing,
Wright-Patterson Air Force Base,
Ohio

I am deeply appreciative of this opportunity to meet with you. This evening I propose to touch upon some aspects of a problem of supreme importance to the strength and welfare of our beloved country for many years to come.

Stated in briefest terms, the problem I propose to discuss is where and how we are going to obtain the hundreds of thousands of technically trained young men and women who will be needed to manufacture and operate the fantastically complex equipment which comprises the civilian economy of the United States and, no less, the Military Forces, and more specifically, the United States Air Force in being which serves as a mighty force to insure that free peoples of the world may remain free.

It may, at first glance, seem strange that I, whose career is that of an Air Force officer trained to fight if necessary to maintain the American way of life should be appearing before your group to discuss a subject which, in essence, is principally concerned with education. Let me, therefore, say the personal word that, for the past year and a half, I have been working night and day to recruit on a voluntary basis the thousands of men and women needed to maintain the United States Air Force at its authorized level of strength. This assignment has been one of the most complex and challenging I have ever been given. At the same time, it has been perhaps the most satisfying experience of my career. Presently, I believe you will understand why we in the Air Force recognize our manpower problem as one in which the education process is a vital factor.

Regarding the need for more and yet still more young men and women with technical training to keep our civilian economy healthy and expanding, or if you will, to provide the manifold "necessities of life" today, which our granfathers could not even envision let alone obtain, it is enough to mention just a few of those articles which within a generation have appeared from the dream world to become necessities: Television, black and white now with color already on the way; wonder drugs that have lengthened so dramatically the life of good health which we and our children now enjoy; miracle fibres

* An address before the Senior High School Group of the Central Association of Science and Mathematics Teachers, Detroit, Michigan, Saturday, Nov. 26, 1955.

that threaten to obsolete nature's wool and cotton; air conditioning which is making comfortable, even at the height of summer's heat, our homes and offices and classrooms. . . . Our way of life has come to depend in an ever expanding way upon the talents of the technically trained.

Similarly, the weapons which comprise the Air Power we have built to maintain the free man's way of life have become enormously complicated. Even when compared to the airplanes we flew in World War II, today's deadly supersonic fighters are as different as is today's television from the crystal and earphones of yesterday's radio.

The design and construction of the airplanes and missiles of today require the labor of many thousands of engineers and highly-skilled craftsmen. The task of maintaining our airplanes and missiles in a high state of operational readiness, no less, requires that the airmen personnel of our Air Force be equipped with a degree of technical competence which, to engage in understatement, is all too rare today.

What I have done is to outline in briefest terms the need, both civil and military, for more and more young people with solid grounding in science and mathematics. What elevates that need beyond what is merely desirable to that which is critical, is the cold, hard fact that half-way around the world another nation is challenging us where we have been strongest—in the fields of technology where, until very recently, we could properly assume a position of supremacy.

Parenthetically, let me say that I believe we have reason for confidence about the superiority of our Air Force . . . today. It is our program of maintaining superiority . . . tomorrow and in the years ahead . . . that is being challenged.

How well we are doing in our job of education, research and development, design and production, and maintenance of operational readiness must be measured not only by the great satisfaction of our nation in the tremendous technical developments which are being born constantly all around us, but also by a realistic comparison of ourselves with Russia.

A factor which favors the U.S.S.R. in the technical race I am talking about is the very great emphasis which the Russians place on science. There is no doubt but that the Soviet Government has recognized the fact that technological superiority in the air rests, in the last analysis, upon a mighty organization of highly skilled personnel, with the designers and the engineers the key element.

Peter Kapitza, the great Russian physicist, spoke of the "special place allotted to science in our socialist country," and then went on to say:—"Of course it is well known and generally expected in other

countries, too, that science plays a great part in the development of culture and technology. It has been allotted the leading part in the development of our technology and economic life. Therefore, the organization of science in our country must be more systematic and conscious of its aims than it is in capitalistic countries where it is rather left to chance and has a spontaneous character. In our county the bonds between science and life must be closer and deeper."

Let us make no mistake, in many scientific fields, Russians are recognized amongst world leaders. They stand high, especially, in mathematical analysis, physics, chemistry, aerodynamics, nonlinear mechanics, and metallurgy . . . all fields of great importance in aeronautics.

They also stand high, these Russians, in the military products of of their technology. The rapid adoption and improvement of the turbojet engine for their MIG fighters, the achievement of an atomic bomb capability in four years instead of the much longer time estimated by our scientists, the development and construction of the long-range turbojet and turboprop bombers which performed this year in the skies over Moscow . . . these serve as convincing evidence that Russia has a great and growing technology.

In a time which President Eisenhower has called an "Age of Peril," we must do more than tally our supersonic aircraft and missiles, and our stockpiles of atomic and thermo-nuclear bombs, against those of Russia. We must look ahead, and ask ourselves how our efforts in the field of scientific and engineering education compare with the efforts of the Soviets.

Here the picture becomes grim indeed. Many of the experts who have scrutinized the facts have concluded that we have already lost the battle for engineering manpower. Dr. John R. Dunning, Dean of the School of Engineering at Columbia University, has called the situation "desperate," and Dr. M. H. Trytten, Director of the Office of Scientific Personnel of the National Research Council, recently said, "The already trained manpower reserves, suitable to be channeled into the sciences and technical fields, are exhausted and can only be replenished by the immediate long-range output of the schools."

Our peak output of engineering graduates came around 1950 when it reached 50,000, a number due in no small way to the many G.I. students who had recognized the importance of engineering and science and who returned to school. Since then, our annual harvest of engineering graduates has slipped until now it is hardly 20,000 a year.

The corresponding statistics for Russia are 28,000 engineering graduates in 1950 and 54,000 in 1955. In numbers, they are producing

$2\frac{1}{2}$ times the American number of engineers today. In absolute numbers, in terms of the total number of Russian engineers compared to American engineers, they have almost caught up with us.

I wish we could take comfort in the belief that the quality of our scientists and our engineers was vastly superior to that pertaining in Russia. But the facts just won't support such a conclusion.

According to Dr. H. Guyford Stever, chief scientist of the USAF, and I quote, "while there are minor differences in the educational material which they cover, the overall quality of a graduate of their system and a graduate of our system appears to be about equal. The current differences in the education system here and there are almost all to the advantage of the scientific and engineering training on their side. As an example, their under-graduate science training runs about a year and a half longer than our American equivalent, and it calls for practical work in industry. As another example, their primary and secondary schools give a much better background in mathematics and the basic physical sciences than do our own."

Soviet Russia has a very definite advantage, too, in being able to direct (I could use instead, and perhaps with greater accuracy, the word, *order*) its young science and engineering graduates into endeavors which the dictators feel require greatest effort.

At the present time they are drafting a large number—the best estimates I have seen range from 20 to 30%—of their technical graduates to become teachers, in the primary and secondary schools as well as in the universities. This, of course, assures Russia of the continuing and expanding supply of engineers and scientists upon whom the Soviets will depend for the size and quality of their air power.

You know, far better than I, how different is the situation here in the United States, respecting the numbers of new teachers of science and mathematics. I have no easy answer for this grave problem other than to say our country's welfare depends upon a speedy solution being found. It is, of course, unthinkable that, in our free society we should have to resort to a draft of our university graduates in order to fill the thinning ranks of your teaching profession.

There are signs that, at last, the critical aspects of this problem are becoming more widely recognized in the United States. Pray God, this recognition will be implemented by wise and vigorous action before we have been outstripped in a technological race, the outcome of which may determine the course of history for centuries to come.

Do not for one moment misunderstand my position. I am concerned, yes, by the current thinning of the stream of technical education, especially when our need is growing. But I am not discouraged. Nor would I, for an instant, think of our adopting the Soviet prac-

tices to solve our educational problems. Within the framework and the processes of our great democracy, we can and we must find the necessary solutions.

Beyond the obvious and immediate need to improve our educational system, there is the requirement, equally urgent, that we employ more efficiently those technically trained people that are available to us.

Respecting this latter need, I should like, in the remaining minutes of my time, tell you a little about what we in the Air Force are doing. First, we seek to place the right man in the right job. Many of you, no doubt, served in the Military Services during the last war. A few of you may even have had a feeling during your hitch in uniform that your talents were not being used to the fullest or wisest extent possible.

Well, and I say this with utmost sincerity, the Air Force and our sister services today are utilizing the available manpower to the fullest extent. It is a matter of necessity. We just cannot afford to do otherwise.

In the Air Force, made up entirely of voluntary enlistments for four years, we have 43 career fields, covering more than 400 specialties (most of them technical). By the most skillful testing procedures that have been devised, we seek to insure that the square pegs are fitted into square holes, and round pegs into round holes.

Then we begin specialist training. Except for the relatively few who already have the necessary technical ability, virtually every Airman can look forward to attending an Air Force Technical Training School, where he will learn skills useful, not only in his period of military service, but also in later civilian years.

Such training is very expensive. The expense of equipping a single man with the varied and sophisticated skills of an electronics specialist may cost as much as $75,000. No wonder we in the Air Force are so strong in our determination to attract young men and women with adequate background training and good growth potential—and, no less, determined that they be encouraged to continue their Air Force career beyond the initial enlistment.

We look, of course, to the secondary schools for the largest number of our new Airmen. But we earnestly hope they will stay in school and graduate before they enlist. If they can, we hope they will go even farther—on to college. We realize that the manpower needs of the Air Force are only a part of the nation's total manpower requirements, and we know that the more college-trained men and women, especially with degrees in science and engineering, the better.

We need, somehow, to perfect our means of communication whereby high school students will learn more about the vocational career

opportunities in the Air Force—just as today they become informed about opportunities in other fields.

Similarly, we need to acquaint your students more vividly with the facts about how more solid grounding in mathematics and the physical sciences will pay off, handsomely, in later years. I am speaking specifically, of course, of the benefits to be had from such emphasis on math and science, as reflected by opportunities in the Air Force. I daresay my comments would possess equal validity respecting jobs in civilian life.

Finally, let me say that even after the Airman has completed his technical training courses and become an effective specialist, we encourage him to continue this process of education. We have thousands and thousands of men and women in Air Force blue who are—on a purely voluntary basis—studying to satisfy the remaining requirements that will assure them of a high school diploma; or are taking courses on the collegiate level. Yes, and there are more than a few Airmen who are working towards advanced degrees.

It has been a privilege to meet with you who are engaged in the teaching profession which is so intimately linked with our nation's welfare. I salute you for your patriotism and your devotion to a most worthy cause.

I wish that what I have said this evening could have been heard, not only by people who are dedicated to the teaching of our youth, but also by the men and women who serve on our school boards, and those private citizens who draw up the budgets of the school systems of our nation.

I have great faith in the way the American people act when presented with the facts. I am confident that respecting this grave problem we have considered tonight, they will act. But adequate action must soon be taken.

We cannot, we shall not lose the race for technical superiority.

I.Q. RAISED AS DRUG QUIETS RETARDED CHILD

A rise in I.Q. of 10.4 points on the average followed treatment of 10 mentally retarded children with one of the new tranquilizing drugs, Dr. Howard V. Bair and William Herold, psychologist, of Parsons (Kans.) State Training School here report in the current (Oct.) scientific journal, *Archives of Neurology and Psychiatry*.

The drug is chlorpromazine, trade named Thorazine.

The scientists attribute the rise in I.Q. to the "removal of severe emotional and nervous disorders which had prevented the students from functioning at their true level of mental ability."

A control group selected to match the Thorazine-treated students with regard to age, sex, and I.Q., was also studied. The I.Q. range in this group was 26 to 88, as compared with 30 to 108 for the experimental group. Upon retesting at the end of the 60-day period, an average I.Q. increase of 2.5 points per student was noted, as compared with the 10.4 points increase in the experimental group.

CIRCLE DIAGRAMS FOR A-C CIRCUIT ANALYSIS

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Circle diagrams of current, voltage, and impedance relations offer a graphic method of analysis that is often helpful in understanding what is really happening in an alternating current circuit. In this discussion we shall first see why the locus is a circle rather than some other curve. After establishing the validity of the method, we shall apply the technique and construct a circle diagram for a typical problem.

Consider a simple series circuit in which the impressed voltage is constant (i.e., a sinusoidal voltage of constant amplitude) and the impedance consists of a resistance R and a reactance X. The general problem is to determine graphically the current vectors in the circuit if either R or X is varied.

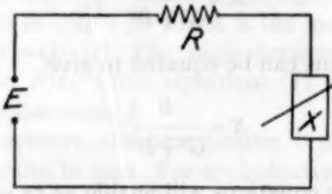

FIG. 1. Simple A-C series circuit.

A brief summary of terminology, symbolism, and basic relations is necessary. First of all, the general expression for Ohm's Law for A-C circuits is $I=E/Z$ where the impedance is complex and is expressed as $Z=R+jX$.

The reactance X may be inductive reactance, which is considered positive and is represented by X_L, or it may be capactive reactance, which is considered negative and is represented by X_C. If the impedance is composed of resistive and inductive elements, the voltage leads the current by a phase angle, $\theta=\text{arc tan } X/R$.

The reciprocal of the impedance is called the admittance, and its symbol is Y. The general expression then becomes $I=EY$. This form of Ohm's Law is convenient for our purpose. The complex expression for the admittance is $Y=G-jB$ where G is called the conductance and B is called the susceptance. Incidentally, here is a good illustration of the generality of complex numbers. Real numbers are a special case of complex numbers. If Z is a pure resistance, $X=O$ and the admittance will be the reciprocal of $R+jO$, which is $G-jO$. In this case the admittance consists of conductance only, and the voltage and current are in phase.

It must be remembered that the instantaneous values of E and I vary sinusoidally. Both can be thought of as rotating vectors differing in direction by the phase angle θ.

From Ohm's Law,

$$Z=\frac{1}{Y}$$

$$=\frac{1}{G-jB}$$

$$=\frac{G}{G^2+B^2}+\frac{jB}{G^2+B^2}.$$

But since Z is also equal to $R+jX$, the real terms in the two expressions are equal so

$$R=\frac{G}{G^2+B^2}. \tag{1}$$

The imaginary terms can be equated to give

$$X=\frac{B}{G^2+B^2}. \tag{2}$$

Analysis of these two equations will enable us to establish the locus. Equation (1) gives the interrelation between the quantities G, B, and R. If we let R remain fixed while X is varied, we can obtain a relation between the two variables G and B. The physical circuit for this situation is shown in Figure 1. Similarly, equation (2) gives the interrelation between the quantities G, B, and X, and, if X is fixed while R is varied, we have another relation between the two variables G and B.

Considering equation (1) analytically, we note at once that it is of the second degree. Rewriting the equation as $G^2+B^2=G/R$ and completing the square, we have

$$G^2-\frac{G}{R}+\left(\frac{1}{2R}\right)^2+B^2=\left(\frac{1}{2R}\right)^2$$

or

$$\left(G-\frac{1}{2R}\right)^2+B^2=\left(\frac{1}{2R}\right)^2, \tag{3}$$

which is the equation of a circle. If we let G be the abscissa and B the ordinate, the graph of this equation is a circle whose center is at $G=1/2R$; $B=0$ and whose radius is $1/2R$. Thus the locus of points

that represent related pairs of values for G and B is a circle. This locus is shown in Figure 2.

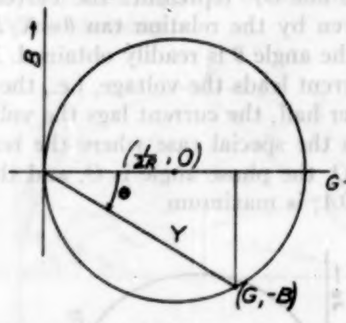

FIG. 2. Basic circle diagram for constant R.

The distance from the origin to the point represented by any pair of values of B and G is $\sqrt{G^2+B^2}$ which is the magnitude of the admittance Y, since $Y=G-jB$. The angle between Y and the horizontal axis is arc tan B/G. From equations (1) and (2) $X/R=B/G$ so this angle is the phase angle θ.

Note that the reactance and susceptance terms in the complex expressions are opposite in sign. For an inductive circuit (X_L positive), the susceptance term is negative, and the lower half of the circle is the locus. Likewise for a capacitive circuit (X_C negative), the susceptance term is positive and the upper semicircle is the locus

We can now use the above relations to find the current locus. If we multiply each term of equation (3) by the impressed voltage E, we have the equation

$$\left(EG-\frac{E}{2R}\right)^2+(EB)^2=\left(\frac{E}{2R}\right)^2 \quad (4)$$

which is the equation of the current.

From the general expression of Ohm's Law, $I=EG-jEB$. EG is called the energy component and EB the quadrature component of the current. In equation (4), if we consider the variables to be EG and EB with E and R fixed, the locus of points representing EG and EB pairs is a circle whose center is at the point $EG=E/2R$; $EB=O$, and whose radius is $E/2R$. The distance from the origin to any point on the circle is the magnitude of the current for any particular value of the phase angle θ, measured from the horizontal axis.

It is apparent that the circle in Figure 3 can be constructed if E and R are known and X is a variable. Thus, for the circuit of Figure

1, the circle diagram in Figure 3 represents the general solution for the current. For each particular value of θ, a point on the circle is determined, and the line OP represents the current vector I. The phase angle θ is given by the relation $\tan \theta = X/R$ so, for any assigned value of X, the angle θ is readily obtained. In the upper half of the circle, the current leads the voltage, i.e., the circuit is capacitive, and in the lower half, the current lags the voltage, i.e., the circuit is inductive. In the special case where the reactance is O, the susceptance is also O, the phase angle is O, and the current, represented by the line OA, is maximum.

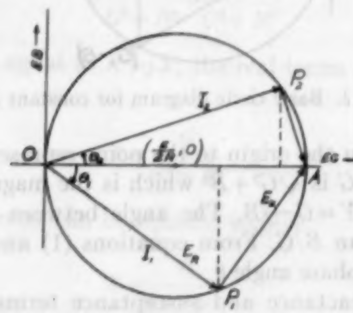

FIG. 3. Current and voltage relations for constant R.

The circle diagram in Figure 3 can also be used to find the voltages appearing across the two circuit elements X and R. From Ohm's Law, $E=IZ$, the voltage drop over the resistance R is the magnitude of the current through R multiplied by R. If we use the same diagram but with the scale of the current diagram multiplied by R, then, referring to Figure 3, the line OP_1 represents E_R, the magnitude of the voltage across R. With this scale, the diameter OA now represents the magnitude of E, the constant applied voltage. Since the vector sum of the voltages across R and X is the constant applied voltage, it follows that the voltage across X is represented by the line P_1A. Thus the lines OP_1, P_1A, and OA are vectors representing the voltages in the circuit. The two voltage vectors E_R and E_X are always at right angles because the angle between them is inscribed in a semicircle.

The following example illustrates the method of analysis. Given an a-c signal of 4.8 volts applied to a simple series circuit consisting of a resistance of 200 ohms and a capactive reactance that is variable, construct the circle diagram for finding current and voltage vectors as X_C is varied. The first step in the solution is to construct the current locus using the known values of E and R. See Figure 4.

Choose a scale so that the diameter OA represents 4.8 volts. For each desired value of the independent variable X_C, a phase angle θ is determined. Lay off this angle at O and then read E_R and E_X directly from the scale drawing.

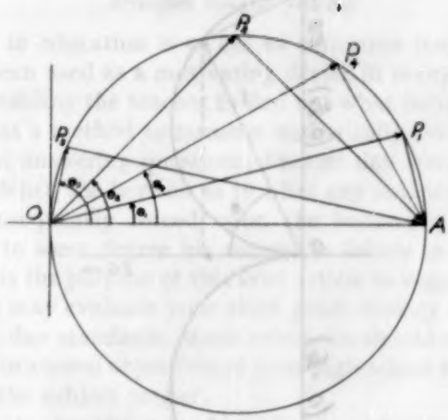

FIG. 4. Example of a graphic solution.

If we wish to find the current, simply measure the line OP using the scale that $OA = 24$ milliamperes. Of course, the circle diagram could be used to find the phase angle or the reactance, if the current were known, by striking an arc from O of length equal to the magnitude of the current. This would determine a point on the circle, and the phase angle could be measured. For example, if the current were 21 milliamperes, the point P_4 is determined and the phase angle of 29° is measured. From the relation $\tan \theta = X_C/R$, X_C is 110 ohms. The following table shows the data obtained from Figure 4.

TABLE I. VALUES OF CURRENT AND VOLTAGE VECTORS FOUND IN THE ILLUSTRATIVE CIRCLE DIAGRAM SHOWN IN FIGURE 4

X_C (ohms)	θ	E_R (volts)	E_X (volts)	I (milliamperes)
50	arc tan .25	4.7	1.2	23
200	arc tan 1.0	3.4	3.4	17
1000	arc tan 5.0	.94	4.7	4.7
110	29°	4.2	2.3	21

The data shown in the above table are of 2 figure accuracy which is all that is warranted since the given applied voltage has only 2 significant digits. Many applications are limited to 2 figure accuracy because of the low precision of the meters used. In cases where 3 figure accuracy is possible, it can be achieved graphically by the

use of a large circle diagram that is carefully drawn. A diameter of the order of 8 inches is recommended. Dividers are convenient for scaling.

FIG. 5. Current locus for constant X.

A similar analysis of equation (2) results in a circle diagram for the circuit with fixed reactance and variable resistance. Rewriting equation (2), completing the square, and multiplying each term individually by the constant impressed voltage E gives the equation of the current locus,

$$(EG)^2+\left(EB-\frac{E}{2X}\right)^2=\left(\frac{E}{2X}\right)^2.$$

In this case, consider the variables to be EG, the abscissa, and EB, the ordinate. The locus is a circle of radius $E/2X$ with center at $(O, E/2X)$ or $(O, -E/2X)$, depending on whether the reactance is capacitive or inductive. See Figure 5. The upper semicircle is for a leading current (capacitive reactance), and the lower semicircle is for a lagging current (inductive reactance).

The graphic method of circle diagrams described above can be extended to the solution of more complex problems encountered in parallel circuits.

A laugh is worth a hundred groans in any market.

—CHARLES LAMB.

EVALUATION IN NINTH GRADE BIOLOGY

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Evaluation in education is as old as education itself. During the years it has been used as a motivating device in many courses, or as a technique enabling the teacher to find out what facts a student has retained and as a method to measure numerically the students relative success at answering questions. Present day educational objectives have widened the horizon as to what any course should accomplish and consequently forced upon the instructor the necessity of measuring to some degree his success or failure in meeting these objectives. It is the purpose of this brief article to suggest a few ideas as to how you may evaluate your ninth grade biology classes according to present day standards. Basic principles should revolve around the general educational objectives of your high school and the specific objectives of the subject proper.

The instructor should list for himself these educational objectives in the student's own language. This can be accomplished by a general discussion with the pupils as to what they expect to acquire from their high school education. A list can be compiled by the class secretary during this activity. The same technique can be used for obtaining the student aims in the course itself. In setting up your evaluating device it is essential to plan the measuring techniques around these objectives.

Individual evaluation can proceed basically along the following method in the two major divisions of measuring what biology should accomplish. Namely, the factual outcomes and the value outcomes.

Measuring of factual outcomes can be accomplished from the knowledge of the individual regarding facts, principles and understandings that are informational in character. These can be measured by the use of achievement tests, oral question, laboratory experimentation, and generalized tests.

Value outcomes or attitudes and habits of social behavior are more difficult to measure and a great deal of teacher observation is necessary to reach a successful conclusion regarding the student in this area. The following suggestions may serve as guides for use in this type of evaluation:

1. Do pupils contribution to class discussion?
2. Does the student find laboratory problems significant for the unit being studied?
3. Does he plan logically?
4. Is his data clear, concise and logical?
5. Does he draw conclusions which the data justifies?

6. Does he contribute by making pertinent suggestions when pupils plan?
7. Does he do his part in experimental work?
8. Does he help willingly to clean up and keep the laboratory orderly?
9. How well does the pupil cooperate with people markedly different from himself—either in race, economic position, social background, intelligence, temperament or interest?
10. Does he frequently speak critically of others when they are not present?

Suggestions for Test Development

The designing of a device for measuring factual outcomes can be enhanced by use of the following suggestions:

1. Keep your objectives ever present, either on paper or clearly in mind.
2. Write your statements or questions on 3 by 5 cards and place the correct answer on each.
3. Arrange these cards according to type—true-false, completion, essay, identification, etc.
4. Place each group of cards in sequence in order of difficulty, easy to difficult.
5. Write out your instructions on cards for each division of the test, clearly and concisely.
6. Type out your test items and instructions, arranging each group so that the answers will be in the same relative position on each page—preferably in the right or left margins. Duplicate or mimeograph.
7. Make a score card of what you believe to be essential for each essay question. This will make your grading more accurate and fairer to each pupil.
8. Complete your answer key on one of the test sheets prior to administering your test and also the numerical value you allow on each division or part of the evaluating instrument.
9. Keep your 3 by 5 cards in a file for future use and reference. Each year you can easily add to this list and eventually develop two or more similar tests of relative difficulty for use in the various sections you teach.
10. Following each test it is a good idea to rank each item according to difficulty from the test results and record on your cards. This makes item arrangement better on repeat tests.
11. Be sure you include some items every student can answer successfully and enough difficult items to provide a definite challenge to your best students.
12. Your evaluating device should be long enough to keep all pupils busy throughout the time you allot for the test.

Evaluation is a never ending process. The purpose for which it is used may vary from time to time. It is a good teaching practice that continues to change and improve in order to meet the educational objective on your particular high school situation and the specific objectives of the subject.

NAIL BROKEN HIP IN 103-YEAR-OLD; HE WALKS

A broken left hip was nailed together in a successful 20-minute operation on a 103-year-old man. Now, almost a year later, the patient is walking about.

His case and those of two 92-year-olds whose broken hips were successfully repaired are reported by Drs. Wilmer C. Edwards, Kilian H. Meyer and Dayton H. Hinke of Richland Center, Wis., in the current *Journal of the International College of Surgeons.*

The case of the 103-year-old may be the first such on record.

THE LECTURE DEMONSTRATION OF BOILING POINT ELEVATION AND FREEZING POINT DEPRESSION

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Texas Technological College, Lubbock, Texas

Previously reported methods for the lecture demonstration of boiling point rise and freezing point depression have proven to be quite inadequate for instructional purposes. The apparatus of Cornog and Hall[1] is cumbersome and does not measure the rise in temperature of the solution, whereas in the method of Devor[2] the

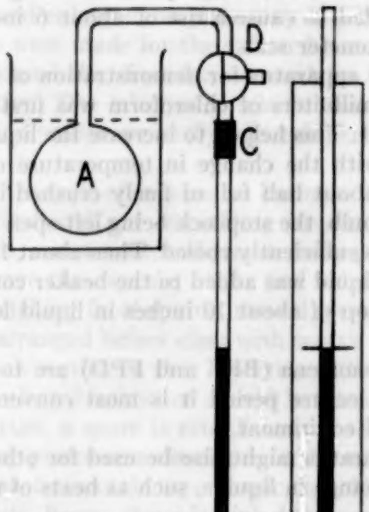

FIG. 1

boiling of the liquid is hardly observable to a large class of sudents. The common use of a small mercury thermometer in detecting the change in temperature of the solution, although visible to the demonstrator, is rarely seen beyond the front row of the classroom.

[1] Cornog, J. and Hall, H., *J. Chem. Educ.*, 4: 245, 1927.
[2] Devor, A. W., *J. Chem. Educ.*, 22: 505, 1945.

To overcome these difficulties, a simple apparatus involving a gas thermometer was constructed as shown in Figure 1. The bulb, A, was made from a 200 ml. round-bottom flask. The U-tube manometer, B., 90 cm. high, was constructed of 7 mm. tubing and connected to the bottom outlet of a three way stopcock, D, by a piece of rubber tubing, C. This connection facilitates dismantling for storage. The manometer indicating liquid was water colored with a soluble dye.

To demonstrate the elevation of boiling point, a one liter beaker containing about 400–500 ml. of water was placed about the bulb, and the water heated to boiling, with stopcock open to the atmosphere. The stopcock was then closed and an electrolyte, such as sodium chloride, was added carefully to the boiling water. A sufficient quantity was added to cause a rise of about 6 inches in the liquid level on the manometer scale.

To prepare the apparatus for demonstration of freezing point depression several milliliters of chloroform was first added to the inside of the bulb, *A*. This helped to increase the liquid level change in the manometer with the change in temperature of the solution. A one liter beaker about half full of finely crushed ice and water was placed about the bulb, the stopcock being left open to the atmosphere until the bulb was sufficiently cooled. Then about 100 ml. of ethylene glycol or similar liquid was added to the beaker contents with vigorous stirring. A drop of about 10 inches in liquid level was observed on the scale.

When both phenomena (BPE and FPD) are to be demonstrated during the same lecture period it is most convenient to have two separate pieces of equipment.

This same apparatus might also be used for other demonstrations of temperature change in liquids, such as heats of mixing or heats of reaction.

ULTRASONIC TORPEDO SEEKS OUT TARGET

An automatic "seek-and-kill" system for submarine torpedoes that uses transistors instead of conventional vacuum tubes has been developed, the Navy announced.

The new guided torpedo system eliminates the need for a 30-second warm-up period before firing. It uses less current and is more compact.

Transistors, which have steadily been taking over the function of vacuum tubes in devices where current and space are limited, are rugged pea-sized gadgets that use semi-conductive germanium crystals.

Developed by Westinghouse Research Laboratories, the torpedo guides itself toward the enemy target with sound waves in the water much like today's modern airborne guided missiles use radar.

CUT OUT LIFE CYCLES

J. Alfred Chiscon
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Simple construction paper cutouts can be highly valuable to the high school biology teacher faced with presenting life cycles of the moss and fern. Too often this phase is omitted by an instructor determined to convince himself that his pupils are unprepared, disinterested or mentally incapable of entering into such supposedly advanced work. Texts themselves can be disheartening to the student facing an arrow-filled diagram containing unseen before sketches and terms.

In an interesting and colorful way, a life cycle can be created step by step, simply and enlarged, on your very blackboard. The answer is cutouts. These were made for the author by occupants of a study period who welcomed the diversion as much as he welcomed their quiet preoccupation. The labor of a science club group, interested biology students, or most assuredly the teacher himself can be as easily utilized.

Let us use the life cycle of moss as an example. Using green paper, figures are sketched and cut resembling oversized individual protonema cells, buds, and a male and female leafy plant. Brown paper is used to construct the capsule, stalk, and rhizoids. Chalk should suffice for the sketching in of spores, the calyptra, and ground line. The cutouts are arranged before class with scotch tape doubled over on the back of each section so that a portion of the gummed surface faces outward. A clean blackboard should be prepared.

During the lecture, a spore is established on the groundline. Cell by cell a branching protonema developes in threadlike fashion. Soon green buds appear by scotch tape magic, quickly growing into a female gametophyte. Brown rhizoids slink downward. The protonema cells are removed. The sexual act is explained as a male gametophyte is established nearby. Another board can be used to present close up sketches of the two sexual organs involved. Back to the cutouts, a stalk is created with a capsule appearing. Spores are formed and released—and so the end and rebirth of the cycle.

Terms may be chalked in to the side of the now complete diagram. These are easily erasable for testing purposes. The diagram itself may be left on the board to further "biologize" your classroom or removed for presentation to the next class. If the board is green in color, a contrasting green construction paper can easily be secured. The life cycles of many plants can be worked out in the above manner, the cutouts being of sufficient durability to last several years.

Here your pupiles have an efficient visual aid. They see growing

before their eyes, structure by structure, parts of a plant they have barely before noticed. Now if they turn to their texts the diagrams will be familiar, the reading material already securely outlined in their notebooks; the life cycle as difficult as a colorful blackboard representation. Laboratory work will then meaningfully bring the plants to them in their miniature reality. Time lost? I doubt it. Even college students could well benefit by this type of initial presentation—especially those not having high school exposure to the material. And most certainly you are not reverting to first grade methods. What a pupil is taught is measured by what that pupil learns. Are you a teacher?

SCIENCE TEACHERS SCHEDULE FOURTH NATIONAL CONVENTION

The Fourth National Convention for all teachers of science being planned by the National Science Teachers Association (NEA) will be held March 14–17, 1956 at the Shoreham Hotel in Washington, D. C. With sessions designed for elementary schools, junior and senior high schools, and colleges, it is expected that 1500 teachers will attend the convention. Convention theme is *Problem Solving—How We Learn.*

Features of the convention will include the annual Exposition of Science Teaching Aids and "interview visits" to several of the research centers in and around Washington. Included in the latter will be the National Bureau of Standards and the National Institutes of Health.

Nationally known scientists and educators, as well as experienced and successful classroom teachers, will give major talks, serve as panel members, and take part as leaders in work discussion groups.

The entire program is being planned to give practical helps for classroom teaching situations and problems. The first day's activities will center about the problem of "Learning How to Find Out." This will be followed by the Laboratory visits and talks by scientists dealing with "Finding Out What Nobody Knows." The third day of the convention will deal specifically with "Finding Out What We Have Learned."

The ever-popular presentation of teacher demonstrations will be retained as a feature of the final day's activities. Film showings throughout the convention period, a display of winning entries in the Future Scientists of America student chart-making contest, and opportunities to visit places of national and historic interest in Washington add to the convention's variety and appeal.

General planning of the convention is by a committee under the chairmanship of Mr. Henry A. Shannon, Advisor in Science and Mathematics, State Department of Public Instruction, Raleigh, North Carolina. Dr. Robert Stollberg, Professor of Science and Education, San Francisco State College, California, is president of the Association which now has over 8000 members. He and the executive secretary of the Association, Mr. Robert H. Carleton, are serving with the committee.

Other committee members are : Dr. Hubert N. Alyea, Princeton University; Dr. Glenn O. Blough, University of Maryland; Dr. Ruth Cornell, Wilmington, Delaware, Public Schools; Dr. Hubert M. Evans, Teachers College, Columbia University; Mrs. Thelma Heatwole, Chairman of the Virginia Academy of Science; Mr. Keith Johnson, Washington, D. C., Public Schools; and Mr. Richard W. Schulz, Emmerich Manual Training High School, Indianapolis, Indiana.

POSSIBLE BOOK AND PERIODICAL CONTAMINATION BY BACTERIA AND VIRUSES

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PROBLEM

To what extent may school books be contaminated by bacteria, viruses, rickettsia, or mycotic infections? Experiments were conducted, in which micro-organisms from the pages of books were washed off, plated out, and cultured. Readings were taken after 48 hours' incubation at both room and body temperature, and then simple determinative diagnoses and comparative numerical estimates were made.

The possible transmission of the dermatrophic and pneumotrophic viruses through contaminated books was considered in connection with their roll as primary or secondary invaders to bacterial diseases.

DISCUSSION

Because so many books circulate in homes, schools, churches, clubs, etc., they are regarded as possible intermittent carriers of fomites of infection. In cases of scarlet fever, diphtheria, poliomyelitis, meningitis and kindred ailments, books found in the rooms of patients so suffering are invariable destroyed or burned. The reason is obvious, for the sputum from such individuals may contain the virulent organisms which may be carried directly by the hands or sneezed or coughed on the leaves of books. Should another person handle the book, he might conceivably inhale the dust or debris particles previously expectorated or sneezed on the book leaves. In the case of tuberculosis it is known that the organism will live for months in dust and dry sputa. Thus a tubercular person who coughs or sneezes on a book may transmit the disease to other individuals who handle it. Furthermore, the person so affected may wet his or her hands or fingers in order to turn the page, and so doing, contaminate the book by direct contact.

METHOD

The pages from various very old school books and some recent ones were collected, preferably from schools and classes where the books had been in recent use by students. For study, the books were classified as having come from libraries, kindergartens and elementary, junior or senior high schools. The oldest books obtainable, which

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were from five to ten years old and falling apart, were given special attention. The leaves were cut to uniform size, under sterile conditions, the hands and scissors previously having been immersed in alcohol. For comparative purposes, four inches square was the size adopted, although in some instances whole leaves were used. A series of test tubes were filled with 5 cc. of sterile water and then labeled to correspond with books obtained from all over the city of Baltimore. Single or part pages were allowed to soak in these sterile tubes for periods varying from 15 minutes to one hour, with frequent agitation. At the expiration of the time intervals, 1/10 cc. of the wash water was plated on either ordinary nutrient agar, cough, or blood agar plates. The usual control plates were set up for culturing with either sterile water or wash water obtained from fresh paper taken out of unused or new books. An alternative experiment was attempted when dirt, grime and dust were scraped from the surfaces of the worst books, weighed, and mixed with sterile wash water for periods of from 15 minutes to one hour. The usual plating was carried out afterwards, using 1/10 cc. of the wash. Mouse inoculation of wash filtrates was made for possible viral pathogens when inclusion bodies were sought.

Results

The results were rather surprising in that ordinary school books showed comparatively few microbial colonies, with only a few pinpoints on the blood plates and occasionally a few hemolytic strains mingled with spreaders and molds. In books not two years old and in good condition, the average number of colonies per 5 cc. on one-hour wash water varied between 700 and 1,000 per full page, practically all of them being "R" type non-pathogens. Some of the elementary school books in recent use revealed pages contaminated by staphylococcic, streptococcic, and diplococcic colonies and some "S" pinpoints. Every plate exposed to page wash water showed a few "R" type subtillis or mycoides colonies, as well as bread and Pinicillum molds. On old or condemned books smeared with visible dirt and grime, the average number of colonies on blood agar plates per 5 cc. of wash water with one hour immersion per page was approximately 10,000 with the "S" pinpoint colonies predominating, and with several hemolytic colonies noted. Old books with glazed-paper pages revealed an average count following one hour washing of approximately 6,000 colonies per 5 cc. of wash water. Again the "S" colonies pinpoints predominated, with hemolytic strains in evidence. No pathogenic viruses were positively indentified, though their presence was suspected in mixed infections such as colds and influenza.

Conclusions

This study suggests that books, not too old or dilapidated, are not serious indirect vectors of infectious diseases. School books that are kept for some time before being redistributed, do not appear to have many viable pathogenic bacteria present on the pages. The organisms that remain for long periods on the surfaces of pages include the spore bearers, Mycobacteria, and the molds. Old books with visible dirt and grime smeared over the surface are capable of harboring many more pathogenic bacteria and viruses than clean or new school books. Old textbooks used from year to year in schools, as evidenced by dilapidated conditions and the pages smeared with dirt and grime, are quite likely to be possible fomites of infection, particularly where recent epidemics have occurred, and the books remain in constant circulation. In all instances the dirt washed off from pages of books of this type showed the largest number of pinpoint and hemolytic strains of possible pathogenic bacteria and evidences of coincident viral infections. School books kept by students from the beginning to the end of the year, or for one semester, and used by one individual only are not dangerous fomites, as ordinarily several days to months elapse before redistribution. The different kinds of paper seem to have some effect upon the length of time bacteria will live on the leaves. Soft crude paper appears to be capable of holding more microbial growth than the partially or high glazed papers.

Recommendations

(1) Old school books frequently exchanged might, to advantage, be opened up and put out in the sunlight for several hours where practicable. (2) Books used by sick children should not be handed out to other students immediately (most Pathogens soon lose their virulence or die out entirely if kept away from the body tissues for some time). (3) Books which are dilapidated, out of date, and filthy with grime should be destroyed. (4) Destroy books coming from quarantined homes, or at least hold them for several months before redistribution. (5) Books used in infectious or communicable disease wards of hospitals should not be redistributed. (6) Books used by people suffering from colds, sore throat, influenza, measles, scarlet fever, whooping cough, diphtheria, meningitis, infantile paralysis, pneumonia, tuberculosis, and books read while convalescing, should be stored for a safe period of time before redistribution. If the home is quarantined, books used by the sick patient should be burned entirely. (7) Books used by pulmonary tubercular patients should, under no circumstances be used by anybody else. (8) When epidemics occur in schools, books from sick children should not be redistributed

until several days have elapsed. (9) Any books used by groups and redistributed several times during a semester should be either sterilized or held for a period of two or three weeks before redistribution, because pathogenic bacteria die out or lose virulence outside of the body. (10) The U. S. Public Health Service advises that books used by patients exposed to infection should be handled with extreme care, disinfected by dry heat, formaldehyde gas, or sprinkled with a few drops of formalin on each page and placed in a closed receptacle for at least 24 hours; that unbound books or pamphlets may be disinfected by live steam. (11) There are two modes of transmission of book bacteria: (a) by direct finger or hand contact and (b) by inhalation of book dust or debris which may contain pathogenic bacteria, viruses, or possibly mycotic infections.

PLANTS COLLECT RARE EARTH METALS

Two University of Wisconsin botanists have found that native prairie plants and virgin forests in Wisconsin and the southern Appalachians literally collect and concentrate the metals known as rare earths, including uranium and radium.

Although no practical application of the knowledge is in sight, Prof. John T. Curtis and Ralph Dix told scientists attending the annual meeting of the American Institute of Biological Sciences that this might be why seedlings of some forest tree species—notably hemlock and yellow birch—mysteriously die, soon after germination.

The Wisconsin scientists used a scintillometer to measure the radioactive metals—uranium and radium—present in the soil at various depths, and conventional chemical methods showed the presence of boron, copper, gallium, lead, silver, zirconium, lanthanum, nickel, vanadium and yttrium.

These metals were present in remarkably high proportions in the uppermost soil layer under both virgin forest and prairie.

The botanists believe these metals are collected along with nutrient minerals by the root network of plants—from as deep as the roots penetrate—and then are deposited on the surface in falling leaves.

Once on the surface, these rare earth metals are taken up by the plant's surface roots and pumped to the leaves, season after season, while the deep roots continue to absorb more metals from deeper soil. In this way, a concentration eventually is built in the soil's topmost layer.

Although they can be detected by sensitive scientific instruments, these metals are present in such small quantities as to be of no commercial value, the botanists caution.

Strangely enough, however, the alpha radiation showing the presence of radioactive metals was found to be most intense under hemlock and yellow birch forests. Here the other rare earth metals were also found in greatest concentration.

It has long been known that seedlings of these two tree species grow successfully only on bare soil or rotting wood. "These seedlings may be unable to withstand the toxicity of the rare metals found in the soil under virgin forest," the Wisconsin botanists reported.

If this is true, it may be possible to devise some methods to insure greater survival of germinated seedlings in these forests, and hence greater productivity, the botanists hinted.

HIGH SCHOOL COURSES IN MATHEMATICS

Marc A. Laframboise
University of Detroit, Detroit, Michigan

There are definite objectives in any secondary education program. Since certain factual knowledge is essential equipment, basic and necessary information must be imparted. Of equal importance is the ability to think in broad conceptual terms and to apply general principles. We must further, then, impart the ability to think clearly and logically.

There are in addition certain skills which are to be at the command of even the moderately literate individual who should be able to converse, and read and write intelligibly, and carry on certain computational work correctly.

A very essential function of the secondary school is to promote the retention of and further develop these basic skills in the fields of language training and mathematical abilities.

The influence of mathematics on our civilization and its prominence to-day indicate the place it might occupy in education. Many reasons both social and special impel that a large number of persons become proficient over a wide range of mathematics. There can be no doubt at all of the value to all persons of any increase in their ability to see and to foresee the manner in which related quantities affect each other.

Unfortunately, mathematics is often described as a difficult subject. There are many abstract ideas to be presented. The facts and principles must be systematically studied. Constant and sustained attention has to be employed. A period of months or years is frequently required to insure mastery.

It would be superfluous to attempt to fully outline the merits of the study of mathematics since the readers of this brief expose are themselves teachers of mathematics or are interested in its presentation. Rather, could we talk of the material which might profitably be outlined to secondary school pupils? Let us first see what we have to contend with in the form of student raw material.

With a view to discussing course work in mathematics could we divide the student body into two broad groups:

(1) Those students who are interested and/or able and

(2) Those students who are disinterested and/or who lack ability?

The former group could include those who intend going to college where a minimum amount of mathematics is usually required, those who envisage work requiring mathematics as a tool, and those who wish to study the subject for itself. The latter group might include those who also may wish to attend college but who have no interest whatever in mathematics and will take little or none if at all possible.

This writer who has been in the teaching profession for some time as an elementary school teacher, as a secondary school teacher, and at this time as an instructor of undergraduate mathematics, believes that all high school students, good or wanting, should be encouraged to study some mathematics in each year of the entire four-year period. Even the poorest student might be well-advised to spend at least the first two years studying some mathematics no matter how modest the content of the course.

Professor C. C. Macduffee of the University of Wisconsin at a symposium in Madison, Wisconsin (8/27/52)* deplored the very spotty preparation in algebra of some of their freshmen. Even among the engineering aspirants the second year in algebra was rapidly disappearing. Even more serious, said Professor Macduffee, was the lack of competence in arithmetic and algebra of those who claimed a year's preparation.

* *American Math. Monthly*, June-July, 53, Vol. 60. No. 6.

At the University of Detroit a mathematics placement test is given to all entering freshmen intending to study some mathematics. These tests over the past five years indicate that the number of students prepared to undertake the study of college mathematics is short of even the 50% mark.

An idea seems to be prevalent that a student should not study anything he might not later use or need. And if a course is at all difficult it need not be presented for fear of attendant frustrations. Students rise to such occasions. More and more topics are found not to be necessary, and more and more studies too difficult.

High school students enter grade IX at about age 14, and it is between the ages of 14 to 16 to 18 that is attained the usual maximal potential as regards intellectual capacity and understanding. It is agreeable to discover what high school students are capable of when something substantial is expected of them.

As a stimulant to thought and study this writer is wont to suggest courses for high school study along the following lines:

Let us consider first the lesser endowed group.

GRADE IX (2 terms)

Arith.—Fundamental operations—integers—fractions—decimals—percentage—weights and measures. Squares and square roots.

Algebra—Introduction and notation. Simple equations. Positive and negative numbers. Construction and use of graphs. Scale drawings. Fundamental operations. Simple factoring. Solution of simple problems from the sciences.

Geometry—Introduction. Simple constructions. Mensuration of triangles, parallelograms and trapezoids.

GRADE X (2 terms)

Algebra—Fundamental operations. Continued factoring. Expansions. Equation solving in one or two unknowns. H.C.F. L.C.M. Problem solving.

Synthetic Geometry—Axioms. Definitions. Congruence cases. Parallelism and related theorems. The parallelogram. Area. Theorems relating to triangles and parallelograms. Geometric proof and practical applications of the Pythagorean theorem.

Analytical Geometry—Coordinates. Graphs. Equation of the straight line, circle, ellipse and parabola. Systems of equations.

Trigonometry—Indirect measurement. Scale drawings. The trig. ratios of 30 degrees, 45 degrees and 60 degrees. Their use.

Mensuration—Triangles, sectors, prisms, spheres, cones and pyramids.

GRADE XI

Algebra—(First term)—Good algebraic foundation through quadratic equations. Fundamental operations. Equation solving. Factoring. Applications. Fractional equations. Surds. Powers and roots. Ratio and proportion. Quadratic equations. Indices and logarithms.

Plane Geometry—(Second term)—Theorems relating to congruence, parallelism, comparison of triangles and parallelograms. Problems relating to the theorem of Pythagoras. Locus problems. Circle theorems: chords, secants, angles, tangents, inscribed, escribed and circumscribed circles. Ratio and proportion. Mean proportional. Rectilineal figures. Similar triangles. Bisector theorems. Extensions of the Pythagorean theorem. Theorems of Ceva and Menelaus.

GRADE XII

Analytical Geometry and Statistics (First term)—Points, areas, the straight line, distances. The simplest elements of the circle, tangents, the parabola, the ellipse and the hyperbola.

Introduction to the basic concepts of statistics. Statistical problems.

Analyzing data. Graphic representation. Concepts relating to sampling and correlation.

Math for Consumers and Business Practices (Second term)—Prices, wages, business cycles, budgeting, installment buying, investments, insurance, taxation, social security, tariffs, and foreign exchange.

Students who so desire and who have the requisite ability could elect the 3rd year courses outlined below of the better group instead of their 4th year courses.

The program for the better-endowed student would parallel that of the first three years of the other, but would proceed at a much quicker pace. It would be possible for students at any time to drop from this program back to the other.

GRADE IX

First term—Appropriate selections from the grade IX program outlined above, extended and enriched if necessary.

Second term—Appropriate selections from the grade X program outlined above, extended and enriched if necessary.

GRADE X

First term—Appropriate selections from the topics of the grade XI algebra outlined above, extended and enriched if necessary. (Progressions. Binomial Theorem)

Second term—Appropriate selections from the grade XI plane geometry course outlined above, extended and enriched if necessary.

GRADE XI

Trigonometry (First term)—Functions, identities, radian measure, double angle formulas, half angle formulas, solution of triangles, inverse functions, trig. equations.

Solid Geometry (Second Term)—Lines and planes in space. Prisms, cylinders, pyramids, cones, spheres and frustums.

GRADE XII

Analytical Geometry and Statistics (First term)—The straight line, the circle, tangents, the parabola, the ellipse and the hyperbola.

Graphs. Frequency tables. Central tendencies. Dispersion. Correlation.

Algebra and Calculus (Second term)—Synthetic division. Remainder and factor theorems. Roots and coefficients. Graphs of polynomials. Approximating real roots. Determinants. Partial fractions.

Basic concepts of the calculus. Limits, differentiation. Maxima. Minima. Velocity. Acceleration. Curve tracing. Points of inflection. Location and number of roots.

Integration. The definite integral and the fundamental theorem. Simple lengths, areas and volumes.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING

Harris Teachers College, St. Louis, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, Harris Teachers College, St. Louis, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Solutions should be in double spaced typed form.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known reference to it.

4. Each solution or problem for solution should be on a separate page.

In general, when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

2461, 2463, 2464. *Felix John, Philadelphia, Pa.*

2461. *Walter R. Warne, St. Petersburg, Fla.*

2466. *Richard H. Bates, Milford, N. Y.*

2467. *Proposed by Howard D. Grossman, New York, N. Y.*

Prove (a) the sum of the areas of any three faces of a tetrahedron is greater than the area of the fourth face; and (b) the plane area bounded by a broken line (or curve) in a plane is the smallest area bounded by that curve.

Solution by Alan Wayne, Williamsburgh Vocational High School, Brooklyn, N. Y.

If A is a bounded plane area, P its projection upon another plane, and θ the angle between the two planes, then $P=A\cos\theta$. Clearly, if $\theta\neq 0$, then, $A>P$.

(a) Project the areas of any three faces of the tetrahedron upon the plane of the fourth face. The areas of the projections at least cover the fourth face area. This proves the desired theorem. (We have applied $P=A\cos\theta$ "in the large.")

(b) We now apply the same relation "in the small." Let $\triangle A_k$ be any portion of the area A of the surface bounded by the given plane curve, and let $\triangle P_k$ be the projection of $\triangle A_k$ on the plane of the curve. Then $\triangle P_k=\triangle A_k\cos\theta_k$, where θ_k is the angle between the normals to $\triangle P_k$ and $\triangle A_k$. In general, $\triangle P_k<\triangle A_k$. Summing both sides of the last inequality form $k=1$ to $k=n$, and proceeding to the limit as n increases without limit, then $P<A$. This proves the theorem. (The procedure is the same in theory as obtaining the double integral for the surface area A.)

2468. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the equation.

$$\begin{vmatrix} 4x & 6x+2 & 8x+1 \\ 6x+2 & 9x+3 & 12x \\ 8x+1 & 12x & 16x+2 \end{vmatrix} = 0$$

Solution by Richard H. Bates, Milford, N. Y.

Two transformations are first made on the determinant in the equation. The first column is multiplied by (-2) and added to the last column. Then the first column is multiplied by $(-3/2)$ and added to the second column. The equation then becomes:

$$\begin{vmatrix} 4x & 2 & 1 \\ 6x+2 & 0 & -4 \\ 8x+1 & -3/2 & 0 \end{vmatrix} = 0$$

Expanding the determinant yields:

$$-64x-8-9x-3-24x=0$$

Hence:

$$x=-11/97$$

Solutions were also offered by Charles Berndtson, Vinalhaven, Maine; Emma Everts, Hammonds Point, N. Y.; A. R. Haynes, Tacoma, Wash.; John Q. Taylor King, Austin, Texas; J. W. Lindsey, Amarillo, Texas; Sister Marcia, Roseto, Pa.; Willis B. Porter, New Iberia, La.; Alice Stevens, Cashtown, Pa.; C. W. Trigg, Los Angeles, Calif.; Walter Warne, St. Petersburg, Fla.; and the proposer.

2469. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the equation

$$\sqrt[3]{6(5x+6)}-\sqrt[3]{5(6x-11)}=1.$$

Solution by Richard H. Bates, Milford, N. Y.

Let

$$y=6(5x+6); \quad \text{then} \quad x=\frac{y-36}{30} \tag{1}$$

and

$$5(6x-11)=y-91. \tag{2}$$

Substituting in the original equation:

$$\sqrt[3]{y}-\sqrt[3]{y-91}=1.$$

Transposing:

$$\sqrt[3]{y}-1=\sqrt[3]{y-91}$$

Cubing:

$$y-3\sqrt[3]{y^2}+3\sqrt[3]{y}-1=y-91.$$

Simplifying:

$$y^{2/3}-y^{1/3}-30=0$$

$$y^{1/3}=6, \quad -5$$

Hence:

$$y=216, \quad y=-125$$

Substituting in (1):

$$x=6, \quad x=-161/30.$$

Solutions were also offered by Charles R. Berndtson, Vinalhaven, Maine; Mary Bonker, Northfield, Ohio; Mae Haggerty, McDuffeetown, N. Y.; A. R. Haynes, Tacoma, Wash.; Tom Kraemer, Iowa City, Iowa; J. W. Lindsey, Amarillo, Texas; Willis B. Porter, New Iberia, La.; C. W. Trigg, Los Angeles, Calif.; Bill Voxman, Iowa City, Iowa; Alan Wayne, Brooklyn, N. Y.; and the proposer.

2470. *Proposed by C. W. Trigg, Los Angeles City College.*

Find the unique permutation of the digits 1, 2, 3, 4, 5, 6, 7, 8, 9, which is one less than the square of a palindromic integer.

Solution by the proposer

If the permutation is P, then $P=(N+1)(N-1)$. Since the sum of the digits of P is 45, either $N-1$ or $N+1$ must be divisible by 9. Furthermore $10108<N<31427$. There are but 42 eligible palindromic integers within this range. Most of these may be eliminated with the aid of a table of squares of four-digit integers, leaving only 13231, 13931, 24542, 25552, and 31213 to be multiplied out in detail. When this is done the unique permutation is found to be

$$974251368=(31213)^2-1.$$

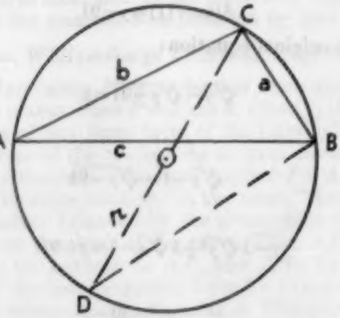
Note: If the palindromic nature restriction on N be removed, then there are twelve more solutions:

$169572483=(13022)^2-1$	$519247368=(22787)^2-1$
$192876543=(13888)^2-1$	$564917823=(23768)^2-1$
$194825763=(13958)^2-1$	$584769123=(24182)^2-1$
$269813475=(16426)^2-1$	$685497123=(26182)^2-1$
$342768195=(18514)^2-1$	$921486735=(30356)^2-1$
$418529763=(20458)^2-1$	$975812643=(31238)^2-1$

2471. *Proposed by J. W. Lindsey, Amarillo, Texas.*

In terms of the sides of a given inscribed triangle, find the radius of a circle.

Solution by Charles H. Butler, Kalamazoo, Michigan.



From any vertex (say C) of the inscribed triangle ABC draw the diameter $CD(=2r)$, and draw chord DB. Then $\angle D=\angle A$ since both are inscribed in the same arc BC.

Therefore

$$\sin A=\sin D=\frac{a}{2r}\cdot$$

Now two different expressions for the area (K) of triangle ABC can be set up as follows:

(1) By Heron's formula

$$K=\sqrt{s(s-a)(s-b)(s-c)}$$

where

$$s=\frac{a+b+c}{2}\cdot$$

(2) By trigonometry

$$K=\tfrac{1}{2}bc\sin A=\tfrac{1}{2}bc\left(\frac{a}{2r}\right)=\frac{abc}{4r}.$$

Therefore

$$\sqrt{s(s-a)(s-b)(s-c)}=\frac{abc}{4r},$$

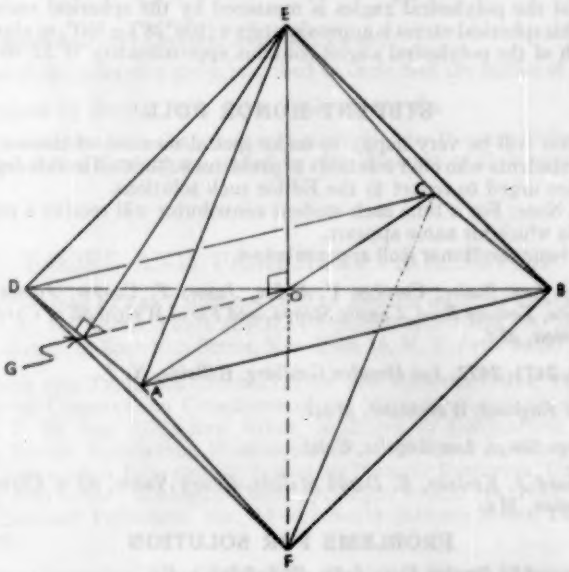
whence

$$r=\frac{abc}{4\sqrt{s(s-a)(s-b)(s-c)}}.$$

Solutions were also offered by Mrs. Stephen Ball, Tecumseh, Mich.; Richard H. Bates, Milford, N. Y.; Carrie Deal, Hayts Corners, N. Y.; Jennie Everts, Everts Grove, N. Y.: Benj. Funnell, McDuffee Town, N. Y.; A. R. Haynes, Tacoma, Wash.; Feliz John, Philadelphia, Pa.; Cassie Munson, East Romulus, N. Y.; C. W. Trigg, Los Angeles, Calif.; Walter Warne, St. Petersburg, Fla.; Alan Wayne, Brooklyn, N. Y.; and the proposer.

2472. ***Proposed by C. W. Trigg, Los Angeles, California.***

Determine the magnitudes of the dihedral angles and of the polyhedral angles of a regular octahedron.



Solution by Charles H. Butler, Kalamazoo, Michigan

Note at the outset the following properties of regular octahedrons which will be regarded as already established:

1. The dihedral angles formed at the 12 edges are all equal.

2. The three diagonals of the octahedron meet in a point (*O*) and are mutually perpendicular bisectors of each other.

3. The plane through two diagonals passes through *O*, contains four vertices

and four edges of the octahedron, and bisects the dihedral angles formed at those edges. The section cut by such a plane is a square.

The notation used in the following solution is that shown on the accompanying figure.

The Dihedral Angles

$ABCD$ is a square with diagonals DB and AC intersecting at O.

$DO=OA$ and $\angle DOA$ is a right angle. Therefore $\angle ADO=\angle DAO=45°$.

Let G be the midpoint of DA.

Then $\angle DGO$ is a right angle and $GO=DG$.

But $GE=(DG)\sqrt{3}$ since $\angle EDG=60°$, whence $GE=(GO)\sqrt{3}$.

Therefore $\angle EGO=\text{arcsec } \sqrt{3}=54°44'$ (approximately) and this is the plane angle of half the dihedral angle E-DA-F.

Therefore dihedral angle E-DA-$F=2 \text{ arcsec } \sqrt{3}=109°28'$ approximately, and since the dihedral angles are all equal, this is the measure of each of them.

The Polyhedral Angles

The measure (in spherical degrees) of any polyhedral angle is given by its spherical excess, which is the amount by which the sum of its dihedral angles exceeds the sum of the angles in a plane polygon of the same number of sides. Now each polyhedral or vertex angle of a regular octahedron has four dihedral angles each of which has been shown to measure approximately 109°28′. Therefore each of the polyhedral angles is measured by the spherical excess of this sum, and this spherical excess is approximately 4 (109°28′) − 360°, or about 77°52′. Hence each of the polyhedral angles contains approximately 77 52/60 spherical degrees.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2468. *Janet Lou Butler, Carolyn V. Cohee, James F. Cooper, James Eveland, Connie Koste, Tommy Reed, Connie Stoops, and Floyd Wright all of Caroline High School, Denton, Md.*

2468, 2469, 2471, 2472. *Lee Dresden Goldberg, Hillside, N. J.*

2468. *Paul England, Worchester, Mass.*

2469. *George Senge, Los Angeles, Calif.*

2469. *Richard J. Kerlake, E. David Mellets, Henry Nuttle, all of Caroline High School, Denton, Md.*

PROBLEMS FOR SOLUTION

2491. *Proposed by Brother Felix John, Philadelphia, Pa.*

Show that a, m_c, and b of triangle ABC cannot form an arithmetic progression.

2492. *Proposed by Hugo Brandt, Chicago, Ill.*

In a parabola $y^2=2px$, if $P_0P_1P_2$ are three points of it so that chords P_0P_2 and P_1P_2 are normal to the curve at P_0 and P_1 respectively, show that

$$x_0x_1=(x_0+p)^2$$

$$x_1x_2=(x_1+p)^2$$

$$x_0x_1=p^2.$$

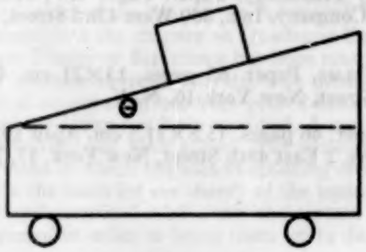
2493. ***Proposed by Willis B. Porter, New Iberia, La.***

If a and b are real integers, express $(re^{\theta i})^{a+bi}$ in the form $A+Bi$ where A and B are real numbers.

2494. ***Proposed by Julius B. Miller, New Orleans, La.***

A block rests on the floor of a cart, the floor being inclined as shown in the figure. The coefficient of friction is u. Show that the maximum acceleration which can be given to the car (toward the left) without causing the block to slide up is

$$a=g\frac{\mu+\tan\theta}{1-\mu\tan\theta}.$$



2495. ***Proposed by J. W. Lindsey, Amarillo, Texas.***

In terms of the sides of a given inscribed triangle find the radius of a circle.

2496. ***Proposed by Brother Felix John, Philadelphia, Pa.***

Find two numbers such that their sum multiplied by the sum of their squares is 5500, and their difference multiplied by the difference of their squares is 352.

BOOKS AND PAMPHLETS RECEIVED

The Expression of the Emotions in Man and Animals, by Charles Darwin, M.A., F.R.S., etc. Cloth. Pages xi+372+8 plates. 13.5×21.5 cm. 1955. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $6.00.

Handbook for Teaching Conservation and Resource-Use, Prepared by The National Conservation Committee of the National Association of Biology Teachers, P. O. Box 2073, Ann Arbor, Michigan in Conjunction with The American Nature Association, Washington, D. C. Richard L. Weaver, Project Leader, Conservation Department, School for Natural Resources, University of Michigan, Ann Arbor , Michigan. Cloth. 499 pages. 15×23 cm. 1955. The Interstate Printers and Publishers, Inc., 19−27 North Jackson Street, Danville, Ill. Price $4.00.

Analytic Geometry, Third Edition, by Charles H. Sisam, *Emeritus Professor of Mathematics, Colorado College,* and William F. Atchison, *Assistant Professor of Mathematics, University of Illinois.* Cloth. Pages xxiv+292. 14×21 cm. 1955. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.75.

The Teaching of General Science in Tropical Secondary Schools, by H. N. Saunders, Mfantsipim School, Cape Coast, Gold Coast. Volume VII. Cloth. Pages xix+379. 13.5×21.5 cm. 1955. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $2.00.

TEACHING SCIENCE TO CHILDREN, by Julian Greenlee, Ed.D.. *Professor of Elementary Science Education, Florida State University, Tallahassee, Florida.* Paper. Pages x+185. 21×28 cm. 1955. Wm. C. Brown Company, Dubuque, Iowa. Price $3.00.

A MANUAL OF PROBLEMS IN STATISTICS, Revised Edition, by Scott Dayton. Paper. Pages v+137. 15.5×23.5 cm. 1955. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y.

PRACTICAL MATHEMATICS REFRESHER, by William D. Reeve, *Professor Emeritus of Mathematics, Teachers College, Columbia University,* and Clarence E. Tuites, *Chairman, Mathematics Committee, and Counselor, Electrical Department, Rochester Institute of Technology.* Paper. Pages viii+376. 15.5×23 cm. 1955. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.25.

CONTEMPORARY FILMS, Paper. 65 pages. 13×21 cm. Contemporary Flims, Inc., 13 East 37th Street, New York 16, N. Y.

NATIVE LAND. Paper. 46 pages. 15.5×21.5 cm. April 1955. National Association of Manufacturers, 2 East 48th Street, New York, 17, N. Y.

BOOK REVIEWS

MARVELS OF INDUSTRIAL SCIENCE, by Captain Burr W. Leyson. Cloth. Pages 187. 39 photo-illustrations; 17 figures and diagrams. 13.0×20.5 cm. 1955. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, N. Y. Price $3.50.

Industrial prodigies frequently have had the cradle of their infancy in the care of the military. Captain Leyson's war assignment initiated his interest in that asset of war industry. He has not dropped it since return to civilian status. This book is another witness to that persistent concern.

If there is coherence in the book's offerings it hinges on the word industrial in its title. The first four chapters have to do with cellulose and its increasing importance in America's economy. Two chapters give glass credit for a growing category of services. The germanium transistor and the atomic battery skirt the field of nucleonics. The gas turbine will bid for mechanical engineers' attention and in silicones the chemists have a last word.

In this small volume the time-limited reader may come by a fuller understanding of the topics enumerated. They are presented in conversational English fairly free from the technical jargon of the specialists. The author keeps clear of the frequently used analogy as a way of avoiding technicalities. He does have some smoke-screen phrases such as, "not too, . . . " and "complex chemical processes" that help get by the explanations that get too heavy. A false sense of wizardry is induced by generous use of: at once, soon, quick, immediately, instant success and suddenly. For this reviewer, inducing the reader to rate the results of science as produced by effortless magic is regrettable. He would also delete, as unnecessary, such superlatives as: marvelous, myriad, fantastic, tremendous, wonderland, infinite, fascinating and amazing. They are more conducive to emotional heat than to rational light. For the casual reader the afore-said may not be an annoyance. Whether that is is true or not, Marvels of Industrial Science will, no doubt, be read with approval by both literate adults and students in our schools.

B. CLIFFORD HENDRICKS
457—24th Ave.,
Longview, Washington

ALGEBRA FOR COLLEGE STUDENTS, Revised Edition, by Jack R. Britton, *Professor of Applied Mathematics*, and L. Clifton Snively, *Assistant Professor of Applied Mathematics*, both of the *University of Colorado, Boulder, Colorado.* Cloth. Pages xiii+537. 14×21.5 cm. 1954. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $4.25.

This textbook is a revision of the one first published by the same authors in 1947. At that time they felt that there was a need for a college algebra text that would give a complete development of the ideas of elementary algebra instead of the usual sketchy review. Therefore, they planned the units of their Algebra in such a manner that the first twelve chapters would furnish an adequate course in intermediate algebra. The last eleven chapters contain the topics customarily covered in college algebra.

In the revised edition most of the chapter on Advanced Topics in Quadratic Equations has been placed into the chapter on Quadratic Equations in One Unknown. The material on Theory of Equations has been rearranged somewhat to present the remainder theorem more effectively. The method of successive approximations to a root of an equation has been placed before Horner's Method, and the development of the latter has been modified. A section on the relations between roots and coefficients has been added. The authors have also added a chapter on partial fractions in which the idea of splitting off one partial fraction at a time has been made the basis for the theory of the topic. The same idea has been used to introduce undetermined coefficients and certain practical shortcuts. Problems have been revised in order to bring them up to date, and others have been added.

The explanations of topics are written for the student but also meet the instructor's requirements for rigor. Teachers familiar with this Algebra will probably agree that the revision has added to the quality of the former edition.

REINO M. TAKALA
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PHILOSOPHY AND ANALYSIS. A Selection of Articles Published in *Analysis* Between 1933–40 and 1947–55. Edited, with an Introduction by Margaret Macdonald, *editor of Analysis.* Cloth. Pages viii+296. 13.5×21.5 cm. 1954. Philosophical Library Inc., 15 East 40th Street, New York 16, N. Y. Price $7.50.

Analysis is a distinguished British philosophical journal which carries articles on analytic and linguistic philosophy. Among other propositions the magazine accepts the proposition that many philosophical problems may be solved by a better understanding of the meaning and varied uses of language. It seemed to be in terms of this proposition that the selection was made of the essays which appear in the book. The essays are on such topics as the relations between knowing, believing, and asserting; meaning; the meaning and nature of truth; probability and natural laws; the analysis of temporal propositions; and the relation of logic, and psychoanalysis and morals.

The essays are not speculative; rather explicative and analytical. They are also esoteric. This latter evaluation is not intended to be derogatory in any sense. It is only to indicate a judgment that they are not the kind on which to begin a study of analytic philosophy or semantics. Those people who would begin this study might do better to warm up on selected chapters in general texts on the subject, e.g., Pap's *Elements of Analytic Philosophy* or Hospers' recent book, *An Introduction to Philosophical Analysis.*

Those people who already have some knowledge of the topics discussed should find the essays rewarding. In a brief review one cannot do justice to the significance of some of the essays. Perhaps it will suffice to name some of the authors, e.g., Ayer, Black, Carnap, Duncan-Jones, Goodman, Lewy, Paul, and Ryle, to bear out the contention.

The reviewer recognized only one essay which has been previously reproduced in books of readings such as Feigl and Sellars, Feigl and Brodbeck, Sellars and Hospers, and Linsky. This was Goodman's "On Likeness of Meaning."

The price of the book appears too high when compared with other books in the same field of similar size and typography. It might be mentioned that the book can be purchased for about three dollars less from at least one bookstore in England.

KENNETH B. HENDERSON
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MEDICINE AND METALLURGY, NOT ALCHEMY, THE SOURCE OF MODERN CHEMISTRY

With its efforts to procure gold and silver from base metals, 16th century alchemy often receives credit for being the source of modern chemistry.

But a University of Wisconsin professor of chemistry pointed to medicine and especially to metallurgy as neglected pillars of our chemical science.

Prof. Aaron J. Ihde, speaking at the 128th annual meeting of the American Chemical Society in Minneapolis, said that the 16th century metallurgist was practically concerned with the extraction of commercial metals from ores, while the alchemist was more of a philosopher, "often more concerned with his concepts than with his operations."

Ihde said that the influence of the smith as a practical chemist was not strongly felt before the 16th century because he was unlettered and left no written works.

The mining and smelting operations in Germany and Italy had reached such proportions by the 16th century that mine supervisors and local physicians began writing about the subject.

"Do it yourself" books for the artisans of that day dealt, for example, with the assaying of metals. These books were important for the practical chemistry they contained, Ihde said.

The scope of "mineralogical arts" including the production of acids, alum, sal ammoniac, vitriols, saltpeter, pigments, and glass, might be considered as important fringe operations of metallurgy, the professor said.

Medical influences, he said, were a second sustaining pillar of chemistry. Often treated by historians of chemistry as "iatrochemistry," the search for chemical medicines spirited by Paracelsus and his followers led to further stress on the importance of chemistry in drug preparation.

The developments in the second half of the 18th century with investigations of Black, Cavendish, Priestly, Scheele, and Lavoisier are generally agreed to mark the beginning of modern chemistry.

"These developments were possible," Ihde said, "because there had accumulated by then a mass of knowledge, largely empirical, about chemical substances, operations, and apparatus which were necessary for further development.

"This knowledge came not from alchemy alone," he added, "but from medicine and metallurgy as well."

FORESEES ONE UNEMPLOYED FOR EVERY ONE EMPLOYED

One unemployed person for every one who is employed is the picture for the future unless steps are taken to employ older people, Vice Admiral Ross T. McIntire (Ret.) predicted at the meeting of the American College of Gastroenterology.

In 20 years, he said, the life span of a man may be 75 and that of a woman 78.

"This will cause us then to have more than 20,000,000 people over the age of 65," he said. "It is reasonable to expect that the health of the older people will be such that they can still work.

"We are giving little thought to the use of the older population. By the year 2000 we may have one unemployed person for every one that is working."

KING OF SPIDERS

HORACE LOFTIN
Science Service Biology Writer

Largest of all the spiders and most formidable in appearance are the huge, hairy tarantulas of the tropics.

The great size and bulkiness of these giants from the spider family Theraphosidae is often amazing. One male tarantula (Theraphosa) captured in French Guiana measured three inches across its body and had a leg span of 10 inches. It weighed nearly two ounces.

Another tarantula (Lasiodora), a female taken in Brazil, could stretch its hefty legs nine and a half inches across. Its body was three and a half inches long and it tipped the scales at almost three ounces, a gigantic weight among the spider clan.

North Americans seldom get to see such tropic brutes except when they are occasionally found as stowaways in bunches of bananas. However, the United States does have about 30 species of junior-sized tarantulas, most of them in the arid Southwest.

The usual diet of most tarantulas consists of bugs and beetles and other crawling creatures, including other spiders. But they do not disdain meals of frogs, toads, mice and lizards when they can capture them. Some of the large tropic forms are known to catch and devour small birds.

Tarantulas may live for many years. In fact, ten years is usually required for them to reach adulthood. In an experiment, one tarantula stayed alive two years and four months without food.

Are tarantulas dangerous to man? They certainly look as if they should be. But experts say they fail to live up to their evil reputation. Their poison is not exceptionally virulent and they are slow to attack.

In fact, says one spider specialist, tarantulas make fine pets and some quickly become tame enough to handle. That may be, but if you must have a tropical pet, better stick to parakeets!

CORPORATIONS ARE GIVING MORE MONEY FOR SCHOLARSHIPS

Corporate giving to individuals and colleges for scholarships and scholarship-support has grown tremendously from about 6 million dollars in 1936 to 40 millions in 1948 to 70 millions in 1953. The 1955 total will be much higher.

WHY THIS GREAT INCREASE?

(1) Recognition of the financial plight of many colleges. One of every 3 freshmen entering college this fall may need financial help. Inflation and the tax collector have reduced income from endowments and made scarce the number of wealthy donors. Zooming enrollments have raised per capita college operating costs 50% since 1948. Thirty per cent of 18-year olds now enroll for college as against 12% in 1930. Tuition fees cover only 50 to 70% of the cost of a college education. Tuition rates have upped less than 25% while total tuition income has dropped!

(2) Conviction of enlightened management that a corporation should be a good citizen and help support worthy projects of general interest.

(3) Decision by the courts that corporate contributions to educational institutions are a right of these corporations under the law, and that these contributions are income-tax exempt under State and Federal law.

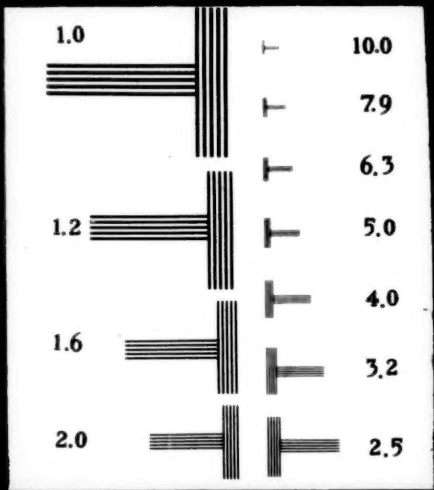
(4) Agreement that business and industry depend on colleges for a flow of trained personnel and new ideas in science, technology, and the arts.

(5) Recognition that educated people help to create a higher standard of living and therefore a better market for the products of business and industry.

(6) Conviction that such contributions tend to promote good will; to flourish, free enterprise needs the sanction of favorable public opinion.

* Based on past experience, these estimates may be regarded as reasonably accurate, the error ranging from about 1 to 5% in the case of elementary-secondary schools, and 5 to 8% in the case of colleges and universities.

RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and 100/20 = 5.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and 7.9 x 5 = 39.5 lines per millimeter recorded satisfactorily. 10.0 x 5 = 50 lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.